FARMERS' CYCLOPEDIA

ABRIDGED AGRICULTURAL RECORDS
IN SEVEN VOLUMES

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AND
THE EXPERIMENT STATIONS

A Compilation of such Bulletins and Reports as are Indispensable to the Practical Farmer

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VOLUME VI

PLANT DISEASES.—
PREVENTION AND CURE.
INSECTS AND INSECTICIDES.
FUNGI AND FUNGICIDES.

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ENTOMOLOGY.

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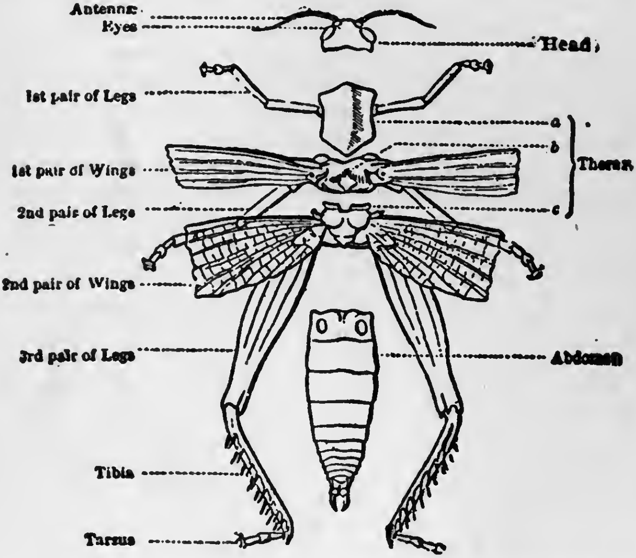
INTRODUCTION.

THERE is a constant and rapidly increasing demand from farmers, horticulturists and others more or less directly interested in insects, or more frequently in the ravages and losses caused by them, for a book giving in a condensed form such information as is required to fight our tiny foes in an intelligent manner. Information of this kind in a printed form is of more utility than any number of letters that might be written, since the illustrations necessary to describe clearly any insect can not well be given in a letter.—(Minn., E. S. B. 28.)

When we consider the immense numbers of insects that exist in all parts of the habitable globe the task, to give in a few printed pages even an outline of their classification, seems to be a more than futile effort. Moreover, any classification of this multitude of forms (one million species of existing insects is not an exaggerated estimate) must be a more or less artificial one.

Geologists speak of the age of shells, of fishes, of reptiles, periods all passed long ago, and they might well call the present geological age the age of insects, because these animals outnumber all others combined. In fact insects are found in every part of the globe that man has ever been able to reach, with the exception of the oceans, where they are replaced by closely allied animals, the crustaceans. And yet, notwithstanding the abundance of insects and their almost omnipresence, how few persons are really able to give a definition of an insect? The term *insect* is derived from two latin words *in* and *seco—cut into,* because the body is *insected* or divided into rings. At one time this term was applied to the entire group of articulates or jointed animals, and consequently early writers spoke of six-legged, eight-legged, many-legged insects. Articulates or jointed animals, which by persons not familiar with zoology are frequently called insects are: Wood-lice or Sow-bugs, Mites and Ticks, Spiders, Harvest-men, Book-scorpions, True-scorpions, Centipedes, Thousand-legs and others not found in Minnesota. None of these animals possess the essential characters of true insects.

At the present time we use the term insect only for those articulates that possess six legs, and that have their external skeleton apparently composed of thirteen joints or rings, which are grouped into three regions, viz: the head, thorax and abdomen. The true insects, or hexapoda, (six-feet) undergo a more or less complete metamorphosis, possess in the adult stage wings, and breathe through a peculiar respiratory system with external openings termed spiracles. All insects are developed from eggs, with a few apparent exceptions; plant lice, for instance, reproduce both by eggs and by budding. The body of an adult insect is divided into three regions, each with peculiar functions. The head contains the organs of vision (compound eyes and simple eyes), the jointed antennæ or feelers, which are the principal organs of touch, smell and hearing, and the mouthparts, organs of taste and feeding. The thorax contains the organs of locomotion—the three pairs of legs and two pairs of wings. The abdomen contains the organs of digestion, reproduction and often of defense. All insects pass through a number of transformations or metamorphoses before reaching the adult or winged and sexual stage. The first of the four principal stages is the egg. In most



A Locust or "grasshopper" dissected to show divisions of body.

cases this is deposited by the female upon the proper food, and is there left to hatch without any further maternal care. In social insects, such as bees, ants, etc., the eggs are taken care of by various methods. In exceptional cases the egg is retained in the oviduct until ready to hatch, or even until it has hatched. The larva (caterpillar, worm, maggot, slug, grub, etc.), hatches from the egg, and it is in this stage of the life of an insect that most growth is made. But as the external skeleton of an insect does not grow the space within soon becomes too small, and the larva has to throw off this old shell and replace it by a new and more commodious one. This action of throwing off the old shell is called moulting, and the process has to be repeated a number of times before the larva reaches its full size. During the larval existence of an insect there is stored up all the material required to produce wings and organs of reproduction, as well as to transform the other organs, as eyes, legs, etc., into their final shape. When fully grown, the larva is transformed into the third stage, or pupa (chrysalis, nymph). In this stage the insect is usually quiescent, at least apparently so, though in reality it is a very active stage, as the most wonderful changes have to take place inside the stiff and rigid pupal shell, and frequently within a very short period. After a certain time the skin of the pupa breaks open, and the fourth and final stage or imago appears, ready to perform all the functions of a winged, sexual insect. Although these transformations seem to be very sudden, they are really nothing but continuous growth, arrested at intervals by the inflexibility of the outer skeleton. The metamorphoses of insects vary very much, and serve as the basis for separating all insects into two groups, those with a complete metamorphosis, as described above, and those with an incomplete one. A complete metamorphosis is one of the most wonderful transformations known to natural history. From an egg hatches a worm-like creature, always hungry, growing rapidly until its full size is attained, when it suddenly stops feeding, and changing to an apparently lifeless object, becomes a pupa. Remaining almost motionless in this condition it breaks open and gives forth a much larger being, possessing many organs not found before in the earlier stages, and able to fly about to mate and deposit again eggs. In a complete metamorphosis the different stages such as egg, larva, pupa and imago do not resemble each other at all. In an incomplete metamorphosis we have no such notable changes of form. The egg hatches into a being that looks very much like the parent, being of course quite small, and lacking all traces of wings or sexual organs. This larva feeds just as ravenously, and has in consequence of its rapid growth also to moult a number of times, and during these slight changes in size it acquires gradually rudimentary wings, which increase in size until the adult stage has been reached. But during this whole period of growth no quiescent state like that of a true pupa appears, and the young insect resembles its parent throughout the period of growth. Butterflies are a good illustration of a complete metamorphosis, and locusts of an incomplete.

The mouth-parts of insects give us also an excellent means for classifying them into three groups. One group possesses a biting and sucking mouth; the second one contains insects which chew their food by means of a pair of horny jaws acting in a horizontal direction; the third group possesses apparently no jaws, and the species belonging here are sucking insects. They obtain their food by piercing and sucking by means of four bristles enclosed in a jointed beak, or fluid food by means of a long and flexible tongue.

But why is it at all necessary to classify insects for any practical purpose? In reply it must be stated that we can not fight against injurious insects with any hope of success if we do not know their structure. For instance, an insect that has no mouth to bite or chew can not be poisoned, and the application of any arsenical insecticides would in most cases be perfectly useless. Nor is it enough to know the structure of the insects; we must also know their habits and transformations, because this knowledge alone will enable us to apply the remedies at the proper time. In fact, notwithstanding the great progress made in economic entomology during the last ten years, we are only able to combat successfully a limited number of injurious insects by means of insecticides. A large number of others, and the most injurious ones at that, can not be reached in that manner. Time, labor and material to do so successfully would cost much more than the whole crop would be worth. The chinch-bug, locusts, and others, if very abundant, can not be fought successfully by means of insecticides. Yet this is no reason why we should not be able to reduce their ravages to a minimum. But without being perfectly familiar with the habits of these insects, with their life-history in all and every detail, including their insect and plant foes, we can not hope to succeed. But by knowing all this we may be able to discover a weak spot into which a wedge can be driven to break up their ranks. Only by attacking the weak spot of a well fortified castle is victory possible.

When we consider the immense numbers of insects, and the fact that they devour every and all kinds of organized matter, it seems almost vain even to try to fight against them. All insects are not, however, enemies to man; on the contrary, the great majority are either indifferent to him, or are either directly or indirectly beneficial. The indifferent ones eat substances we can not or do not use; the beneficial ones eat noxious plants, decaying substances, or live in the bodies of other insects, thus purifying the air and making space for other living organisms. Without them the soil would be covered with dead vegetable matter, the now existing plants, i. e., those that are fertilized by the wind, would become smaller and smaller, because their seeds, not eaten by insects, would all have an opportunity to grow, thus crowding, dwarfing and killing each other. Without insects the great majority of our brightly colored flowers would not produce seeds, as most of them are dependent upon the work of these animals to cause cross-fertilization.

The question is frequently asked: Why is it that farmers, horticulturists, gardeners, etc., are more troubled in the United States with noxious insects than they are elsewhere? or Why is it that more injurious insects and of different kinds are found now than formerly? The reasons for this increase of insects, both in numbers and kinds, are not so very difficult to give. When settlements were few and widely scattered, the whole country was covered with its virginal vegetation. Plants and animals were adapted to each other, and as soon as one of them became for any reasons exceedingly numerous, natural checks in the form of enemies to such plants or animals soon reduced them to their normal numbers. In a state of nature plants distribute themselves in such a manner that one kind never occupies the ground exclusively. Our native forests are not composed of one species of trees, but of very many kinds, in constantly varying proportions which depend upon the character of the soil and the needs of the different kinds of trees. The same is true of the plants that clothe our beautiful prairies. Notwithstanding the uniformity of the soil the prairies are covered here and there with different plants. Animals, and chiefly insects, depending directly or indirectly upon plants, naturally follow their distribution. When the sod of our prairies was broken to receive the seeds of plants not grown there before, the soil responded freely to the new demands and yielded phenomenal crops. This prospective reward for agricultural toil soon attracted more and more farmers until the prairies were teeming with human beings, eager to mine the golden grains—the only form of mining that will make a people really happy and prosperous. But in cultivating more and more soil, man destroyed the finely balanced relation between the animal and vegetable kingdoms by adding a disturbing factor. At first but few destructive insects to the new crops were found, because they had to be introduced from elsewhere; but as soon as they found this Eldorado—an immense area covered with the best kind of food for them—they were not slow to appropriate to themselves what was not planted for them. Insects of all kinds, but at first mainly injurious ones, will invariably take possession of fields where plants of one kind are grown upon a large scale. Insect foes of such plants will soon find their way to such fields and fix there a new home. In course of time, however, things will change for the better, simply because the foes of such newly introduced species will also make their appearance and wage war upon their old enemies. This is one reason why in the older settled parts of the globe insect outbreaks are less frequent, though they are by no means unknown. The disturbed relationship between plants and animals has there become re-established. Moreover a more diversified farming is the rule in older countries, and insects there do not find such an abundance of food as where their food is grown upon a very large scale.

Imported insects usually become injurious because their natural enemies are left behind in the natural habitat of the pest.

To enable the reader to recognize his friends and foes amongst insects the following two artificial classifications are given. Both are very simple, and the study of insects, in most cases, requires no magnifying glasses. It is best to compare with both classifications any insect to be located, that no errors be made. Both classifications apply only to the adult or winged insects.

I.

Insects with both a biting and sucking mouth:	
Wings with veins:	*Hymenoptera.*
Insects with a biting mouth:	
Upper wings horny:	*Coleoptera.*
Upper wings like pergament:	*Orthoptera.*
Upper wings with many veins:	*Neuroptera.*

Insects with a sucking mouth:
- All wings scaly: *Lepidoptera.*
- Only two wings: *Diptera.*
- Upper wings half leathery and half membranous: *Hemiptera.*

II.

1. With two wings: *Diptera.*
2. With four wings:
   - A. Upper and lower similar:
     - a. All wings scaly: *Lepidoptera.*
     - b. All wings naked or a little hairy:
       1. Wings with numerous veins: *Neuroptera.*
       2. Wings with few veins: *Hymenoptera.*
   - B. Upper and lower wings dissimilar:
     - a. Mouth-parts forming a sucking tube: *Hemiptera.*
     - b. Mouth-parts not forming a sucking tube:
       1. Upper wings horny: *Coleoptera.*
       2. Upper wings like pergament: *Orthoptera.*

(Bul. 28 Minn. Agr. Exp. Sta.)

METHOD OF USING THIS VOLUME.

To determine what insect or disease is injuring your crops and the methods of prevention or cure, first carefully note the nature of injury to the particular crop. Then secure specimens of the injured plants and look for the pest. When you find the insect, if such be the pest or the diseased portion, if no insect is discovered, go to your library, get down this volume and look in the index for the name of the plant affected. Turn to the page indicated and read carefully through that portion until you come to the description of an injury which appears to be identical to that you have in hand. Read this over carefully and apply the remedy given. Be sure to note whether any cultural directions are given, regarding the future treatment of this specific crop, that will help to insure the freedom of the plant from this kind of an attack another year.

Example.—Your wheat appears yellow and is falling down badly. Examine the fallen stalks carefully. You find that [illegible] base are several constrictions and in the sheaths are small brown bodies, like flax-seed. Going to your library you turn to wheat insects and find that the description of the injury by the Hessian fly corresponds to the injury in your grain. The remedy given is to burn the stubble after harvesting to kill many of the second brood; in addition, the volume tells you to plant your wheat that fall as late as possible, without endangering your grain by winter killing. This late planting prevents the second brood from depositing eggs which will hatch the following spring and injure the grain another year.

In any case the remedy will be given following each insect but for a complete discussion of the formulas and methods of making and using the various insecticides, consult the sections on the preparation and uses of insecticides, pages 362-399 and 656-666.

THE ANNUAL LOSS OCCASIONED BY DESTRUCTIVE INSECTS IN THE UNITED STATES.

INTRODUCTION.

In no country in the world do insects impose a heavier tax on farm products than in the United States. The losses resulting from the depredations of insects on all the plant products of the soil, both in their growing and in their stored state, together with those on live stock, exceed the entire expenditures of the National Government, including the pension roll and the maintenance of the Army and the Navy. Enormous as is the total value of all farm products in this country, it would be very much greater were it not for the work of these injurious insects. The statistics of agricultural products for the year 1889, of the Twelfth Census, and for subsequent years, gathered by the Bureau of Statistics of the Agricultural Department, indicate an annual value of all the products of the farm of about $5,000,000,000. To one familiar with the work of the important insect pests of the different agricultural products entering into this total it is comparatively easy to approximate the probable shrinkage due to insects. The detailed consideration of such shrinkage which follows indicates that they will rarely fall below 10 per cent, and in years of excessive insect damage may amount to 50 per cent or even more of the important staple products of the farm. An annual shrinkage of 10 per cent is a low estimate, which is more often exceeded than fallen below, and indicates, at current farm prices, a money loss of $500,000,000—the minimum yearly tax which insects lay on the products of the farm. This total comprises, however, only losses suffered by the growing and maturing crops and annually by live stock, and does not include two very considerable and legitimate items, namely, the loss occasioned by insect pests to farm products, chiefly cereals and forage crops, in storage, and to natural forests and forest products. As shown in the consideration of these two sources of loss presented below, at least $100,000,000 must be assigned to each, making a total annual tax chargeable to insects of $700,000,000. —(Reprint Y. B. Dep. of Agr. 1904).

BASIS OF ESTIMATES.

Throughout this work the estimate of losses in dollars is based on the farm price of the crop actually harvested, and does not, therefore, take into account the possible reduction in value which would follow the marketing of the larger crop. While it is true that prices are regulated by production, the factor of distribution may often predominate, so that large crops in certain countries may sometimes bring good prices and small crops low prices. During the ten years previous to 1904, for example, the price of wheat in this country exhibited little if any relation to our own production. The bumper wheat crop of 1901 of nearly 750,000,000 bushels brought to the farmer 23 cents a bushel more than the crop of 1894, which was 300,000,000 bushels less, or but little more than half the production of 1901; and in 1904 the farmer received nearly $1 a bushel for his wheat on a crop larger than the average

Some definite means of estimating losses must be assumed, and any effort to scale down these losses by reckoning possible enhancement of the market price in view of the conditions just cited would come more in the category of pure guesswork and be open to quite as great objection as the plan adopted. As an offset to possibly enhanced values due to shrinkages occasioned by insects, moreover, are certain very legitimate items of cost. A very considerable item of loss properly chargeable to insects is the annual expenditure devoted to their control, which, except in the case of certain fruit and truck crops, has not been considered in the estimates. This amounts to a very considerable percentage of the value of the crop in the case of orchard fruits, truck crops, and such field crops as cotton and tobacco. In the case of the cereals, protection is chiefly secured by farm practices, such as rotation of crops, variations in the time of planting, etc., and this also applies, to some extent, to cotton, tobacco, and truck crops. In estimating the losses due to the codling moth, for illustration, it is shown that over $8,000,000 a year is expended in spraying apple trees, allowing a cost of only 5 cents per tree. In the case of citrus fruits the cost of gassing and spraying ranges from 5 cents to $1.50 per tree.

Another legitimate class of losses not included in the estimate is the secondary losses which necessarily result from diminished products. For example, the excessive reduction in winter wheat through the Hessian fly ravages in 1900 put a serious check upon milling operations throughout the region worst affected and caused very heavy loss in this field of industry. Similarly a shortage of cotton may so increase the values as to lead to the shutting down of cotton mills. A shortage of grains means a corresponding loss to the railroads and other transportation companies and to shippers. In other words, any material shrinkage in an important product starts a train of losses to the end of the chapter, the total amount of which is quite beyond calculation or estimate.

It is believed that these omitted items of loss will make good any difference of price which might result from the larger crops if insect damage were entirely eliminated. Outside of the cash value of the crop, furthermore, is the actual material loss in products, which is absolute so far as the consumer is concerned. The importance of this loss will vary with the nature of the crop. With perishable products, such as fresh fruits and vegetables, the losses due to insects may be of minor importance. For example, if the apple crop were increased by 25 or 50 per cent of marketable fruit, values would probably shrink a corresponding amount, and the demands of consumption and the possibilities of storage be very greatly exceeded, so that there would actually be very little benefit, if any, to the producer. On the other hand, in the case of staple products of long keeping quality, as grains, cotton, sugar, lumber products, etc., the loss may be reckoned as more nearly complete, and the chief loss due to insects falls in this latter class.

RESULTS OF CONTROL OF INSECTS.

Enormous as is the annual loss which may now be fairly charged to insects, it would undoubtedly be vastly greater if such pests were left absolutely unchecked and no efforts were made to limit their operations. Were it not for the methods of controlling insect pests, resulting from the studies of the Bureau of Entomology and of the official entomologists of the various States, and the practice of these measures by progressive farmers and fruit-growers, the losses from insects would be greatly increased. Familiar illustrations of savings from insect losses will occur to anyone familiar with the work in economic or applied entomology in this country. The cotton worm, before it was studied and the method of controlling it by the use of arsenicals was made common knowledge, levied in bad years a tax of $30,000,000 on the cotton crop. The prevention of loss from the Hessian fly, due to the knowledge of proper seasons for planting wheat, and other direct and cultural methods, results in the saving of wheat to the farm value of from $100,000,000 to $200,000,000 annually. Careful statistics show that the damage from the codling moth to the apple is limited two-thirds by the adoption of the arsenical sprays, banding, and other methods of control, representing a saving of from $15,000,000 to $20,000,000 in the value of this fruit product alone. The existence and progress of the citrus industry of California were made possible by the introduction from Australia of a natural enemy of the white scale, an insect pest which was rapidly destroying the orange and lemon orchards, this introduction representing a saving to the people of that State of many million dollars every year. The rotation of corn with oats or other crops saves the corn crop from the attacks of the root worm to the extent of perhaps $100,000,000 annually in the chief corn-producing regions of the Mississippi Valley. The cultural system of controlling the boll weevil is already saving the farmers of Texas many millions of dollars, and, in fact, making the continuance of cotton growing possible; and scores of similar illustrations could be cited.

The losses occasioned by insects to farm products exhibit a wide range in different years, due, as a rule, to favorable or unfavorable climatic conditions, and also to the abundance, from time to time, of natural enemies. The result is more or less periodicity in the occurrence of bad insect years. In other words, periods of unusual abundance of particular insect pests are, as a rule, followed by a number of years of comparative scarcity. Furthermore, seasons which may be favorable to one insect may prove unfavorable to others, hence there may be not only periodicity in the occurrence of the same insect, but more or less of a rotation of the different insect pests of particular crops.

CONCLUSIONS.

A general analysis of the insect losses for this country has been given in the introductory paragraphs. In concluding it is only necessary to emphasize again the fact that these losses, enormous as they are estimated to be, could be legitimately swelled by adding the secondary losses which, in the case of the great staple productions of the farm, follow any considerable shortage and ultimately add to the cost of living for every individual, in addition to creating large commercial disturbances. Furthermore, the cost of protection from insect damage has been considered only in the case of one or two products of the farm. Another considerable insect tax not estimated for is the direct loss and the cost of protection from domestic or household insect pests. Screening of houses against mosquitoes or flies, protection from roaches, clothes moths, and the ravages of the white ant and of various parasitic insects, are a charge on every household. The white ant in Washington, D. C., alone causes losses of thousands of dollars yearly, and it is much more destructive in southern districts. If the smaller or larger sums expended for protection from such pests were tabulated for the whole country, the total would probably exceed $50,000,000, and might be double that amount. An omission perhaps more important than any of these is the indirect loss to the producing and earning capacity of communities by diseases conveyed by insects. For example, malaria and yellow fever are dependent solely on certain species of mosquitoes, and typhoid fever is commonly carried by house flies. The losses from all three of these diseases are enormous, and in the case of yellow fever outbreaks, often almost beyond computation. With domestic animals the tick, responsible for Texas fever in the South, has been estimated to cause an annual loss of $100,000,000, and other diseases of man and domestic animals will undoubtedly be shown to depend exclusively or largely on biting or other insects. In view of these omissions, it is certain that the total of over $700,000,000 annual loss assigned to insect pests in America is below rather than above the actual damage. The lessening or prevention of this loss is the problem for the economic entomologist to solve.—(Rep. Y. B. U. S. D. A. 1904.)

RELATION OF INSECTS TO DISEASE.

It has been definitely ascertained that malaria and yellow fever are transmitted to man by the bites of certain mosquitoes and that one of the three chief sources of the transmission of the germs of typhoid fever is the house fly.

The old idea that malaria is caused by breathing the miasma or mist of swamp has been exploded. Malaria is contracted only through the bites of mosquitoes of the genus Anopheles. The disease is caused by the introduction into the blood, through the bite of the mosquito, of many small one-celled animals which destroy the red corpuscles of the blood of man. In order to avoid the disease, it is only necessary to avoid the bites of the insects. Mosquitoes are bred in stagnant water mostly and can be prevented by thorough drainage, where feasible or by spraying oil on the water. Proper screening of habitations is also necessary.

One of the most important of these disease-transfer relations of insects which has been demonstrated is the carriage of yellow fever by certain mosquitoes. The cause of yellow fever has always been a mystery, and indeed it is a mystery to-day in a measure, since, although undoubtedly a disease of parasitic origin, the parasitic organism itself has not yet been discovered. During the summer and autumn of 1900 and spring and summer of 1901 the work of a commission of surgeons of the United States Army demonstrated in Cuba beyond the slightest possible doubt that yellow fever is not conveyed by infecting clothing of yellow-fever patients or by contact with such patients or by proximity to them, but that it is conveyed by the bite of a certain species of mosquito known as *Stegomyia calopus,* which abounds in regions where yellow fever is possible. The bite of this mosquito, however, does not convey yellow fever to a healthy person until twelve days have elapsed from the time when the same mosquito has bitten a person suffering with the disease. It follows from this fact that by keeping yellow-fever patients screened from the possibilities of mosquito bites we can prevent the yellow-fever mosquito from becoming infected. It follows further that by preventing healthy people from being bitten by mosquitoes we can keep them free from the disease even where infected mosquitoes exist. And it follows still further that by the adoption of remedial measures looking toward the destruction in all stages of the yellow-fever mosquito we may reduce to a minimum the possibilities of the transfer of the disease. After demonstrating the fact, the medical officers of the Army in Cuba put these measures into effect, and the results were most gratifying. The health of Havana immediately improved, and the general health of Cuba and the industrial conditions dependent upon better sanitation have continually gained since.

The New Orleans outbreak of yellow fever in the summer of 1905 was quickly stopped by antimosquito measures, and it is conceded that more than 4,000 lives were saved in that city during that season by the intelligent application of measures based upon the discovery of the United States Army surgeons in Cuba in 1900 and 1901.

TYPHOID FEVER.

The principal insect agent in this spread is the common house fly, and this insect is especially abundant in country houses in the vicinity of stables in which horses are kept. The reason for this is that the preferred food of the larvæ of house flies is horse manure. House flies breed in incredible numbers in a manure pile, largely derived from horses. Twelve hundred house flies, and perhaps more, will issue from a pound of horse manure. Ten days completes a generation of house flies in the summer. The number of eggs laid by each female fly averages 120. Thus, under favorable conditions, the offspring of a single over-wintering house fly may in the course of a summer reach a figure almost beyond belief. With an uncared-for pile of horse manure in the vicinity of a house, therefore, flies are sure to swarm. Their number practically will be limited only by breeding opportunities. They are attracted to, and will lay their eggs in, human excrement. Under favorable conditions they will breed, to some extent, in this excrement. They swarm in kitchens and dining rooms where food supplies are exposed. They are found commonly in box privies, which sometimes are not distant from the kitchens and dining rooms. Therefore, with an abundance of flies, with a box privy near by, or with excremental deposits in the neighborhood, and with a perhaps unsuspected or not yet fully developed case of typhoid in the immediate neighborhood, there is no reason why, through the agency of contaminated flies alighting upon food supplies the disease should not be spread to healthy individuals. That it is so spread is not to be questioned. That under the unusual conditions of the army concentration camps in the summer of 1898 it was so spread to a shocking extent has been demonstrated by the army typhoid fever commission. And the remedy is plain. It consists of two courses of procedure: (1) Proper care of excreta; (2) the destruction of flies.

On many farms where intelligent people live the old-fashioned box privy has been done away with, and there has been substituted for it some form of earth closet. Where a good earth closet is in operation, and the inhabitants of a farm appreciate the importance of using no other, and where in case of illness the excreta of patients are promptly disinfected, flies breeding in the neighborhood will have practically no opportunity to become contaminated with typhoid germs, except in the unlikely event (which future investigation may possibly show) that other animals than man are subject to this disease. The proper maintenance of an earth closet will add somewhat to the work of a farm, but this extra work will pay in the long run. While it is true that a box inclosure, if its contents are covered with lime every three or four days, will answer the purpose, a much better plan would be to use a large metal vessel, the surface of the contents being covered with earth after each operation, and which may be removed, emptied, and replaced daily. Care should, of course, be taken to empty the contents of the vessel in a pit constructed in some well-chosen spot, from which the drainage would not be dangerous.

With regard to the abolition of flies, the best measures will again naturally involve some trouble and expense. In a thickly settled country it will become necessary for some such measure to be generally adopted in order to be perfectly effective, but in an isolated farmhouse the number of house flies may be greatly reduced by individual work. All horse manure accumulating in stables or barns should be collected, if not daily, at least once a week, and should be placed in either a pit or vault or in a screened inclosure like a closet at the side or end of the stable. This closet should have an outside door from which horse manure can be shoveled when it is needed for manuring purposes. Each day's or each week's accumulations, after they are shoveled into the closet or pit, should be sprinkled over the surface with chloride of lime, and a barrel of this substance can conveniently be kept in the closet. If this plan be adopted (and these recommendations are the result of practical experience), house flies will have almost no chance to breed, and their numbers will be so greatly reduced that they will hardly be noticeable. Many experiments have been made in the treatment of manure piles in order to kill the maggots of the house fly, and the chloride-of-lime treatment has been found to be the cheapest and most efficacious.

It has been stated above that the closet for the reception of manure should be made tight to prevent the entrance or exit of flies. A window fitted with a wire screen is not desirable, since the corroding chloride fumes will ruin a wire screen in a few days.—(Farmers' Bul. 135.)

INSECTS INJURIOUS TO FRUIT.

APPLE INSECTS.

The Woolly Aphis.—Throughout the summer on the lower portion of the trunk and particularly on the water sprouts of the apple may often be seen small bluish-white flocculent or cottony patches, which indicate the presence of colonies of one of the worst enemies of the apple, viz., the insect variously known in this country as the apple-root plant-louse, woolly apple-louse, woolly aphis, etc., and abroad very generally as the American blight. It exists in two forms, the one just referred to, above ground on the trunk or water shoots, and another inhabiting the roots and not open to observation. Closely paralleling in these particulars the grape phylloxera, the damage from the woolly aphis is also almost altogether due to the root form, the aerial colonies causing scarcely any injury. On the roots its attacks induce enlargements or galls or swellings very similar to those produced by the phylloxera, and in the cracks of these galls and swellings the root form occurs in clustered masses. The injury to the trees is due both to the sucking up and exhaustion of the vital plant juices and to the poisoning of the parts attacked, as indicated by the consequent abnormal growths. The woolly-aphis of the apple is found in nature in two so-called forms. One infests the limbs and twigs, while the other lives under the ground upon the roots. The presence of the aerial form of the woolly-aphis is readily detected by the bluish-white cottony or downy looking substance that is excreted by and covers the greater part of each wingless individual aphis; and since these insects live in clusters or colonies, the patches of white matter are very conspicuous, and can scarcely escape the notice of even the most casual observer.—(Mo. E. S. B. 35; Dept. of Agr. Cir. No. 20, B. E.)

The presence of the root inhabiting form is readily detected by removing the earth from the roots near the trunk of the infested tree. The appearance of a bluish-white cottony or mildew looking substance, or of knotty and distorted roots will indicate its presence. It is this root or subterranean form that causes so much damage to the apple orchards in the southern half of Missouri, and to apple nursery stock throughout the state. The infested apple tree appears sickly; it does not grow as it should; its leaves are less numerous and they have more of a pale green or yellowish color than is natural; and finally the tree dies outright or is blown over with the first slight wind.

The woolly-aphis sucking the juices from the roots of the apple tree causes an abnormal growth of the attacked portion of the roots resulting in the formation of gall-like swellings or excrescences. These swellings are usually irregular and knotty in appearance and sometimes attain considerable size, while that portion of the roots between the excrescences is frequently undeveloped.

After planting, if the trees be kept in vigorous growing condition by careful cultivation and, if necessary, proper fertilizing, damage from the aphides is much less apt to occur, and the principal danger period, namely, the first two or three years after planting in the orchard, will pass in safety. The value, as a means of protection, of thorough cultivation and good care of young orchards can not be too strongly insisted upon. Vigorous growing trees have a decided power of resistance and are able to sustain with comparatively little damage the presence of the root-aphides, while illy-cultivated and neglected orchards are especially liable to injury.

In planting apple trees tobacco dust should be freely used among and over the roots, and close around the trunk, in order to kill and prevent the woolly-aphis from establishing itself there.

The root form of the woolly-aphis may be cheaply and easily killed and kept away from an apple tree by the liberal use of tobacco dust. About five or six pounds of this substance should be applied as above directed to the roots of every infested tree, and one-half this amount should be applied in a similar manner each succeeding spring, costing approximately two cents per tree per year.

The other sprays may be used after the trees are in full leaf in the following proportions: Kerosene emulsion that is one-fifteenth kerosene; fish oil and whale oil soaps in the proportion of 1 pound to 8 gallons of water, and tobacco decoction in the proportion of 1 pound to 4 gallons of water.—(Col. E. S. B. [Press] 31; Mo. E. S. B. 35; Dep. of Agr. B. of E. Cir. 20.)

The Round-Headed Apple-Tree Borer.—The first intimation that the grower may have of the presence of this borer in his trees, unless he be forewarned, is in their retarded growth and the saw-dust-like castings, consisting of excrementitious matter and gnawnings of woody fiber, which the larvæ extends from the openings into their burrower. The parent of this borer is a beautiful beetle, measuring from three-fourths to nearly an inch in length. The upper surface is light yellowish brown with two longitudinal white stripes extending through the thorax and elytra or wing-covers to the tip. The larva, when mature, measures from three-fourths to a little over an inch in length. This borer is practically limited in its food to the apple and kindred woody plants. It is most injurious to quince and apple, and somewhat less so to pear. This species inhabits more particularly the base of the trunk of trees, often being found below the surface of the earth, especially in young nursery stock. The larvæ, soon after hatching, tunnel under the bark and feed on the sap-wood, gradually working their way upward and afterwards downward, usually remaining within a short distance of, or below the surface of the ground, particularly in young trees. One-third the larvæ gnaw outward to the bark * * * and issue through a round hole as mature beetles.—(32 3rd Revise U. S. Dept. Agr.)

Any one of several washes in general use against boring insects may be used as a deterrent. A good alkaline wash is prepared of soft soap reduced to the consistency of thick paint by the addition of caustic potash or washing soda in solution. A good fish-oil, or whale-oil, soap, or common soft soap, is often used, and in some cases any one of these is sufficient to deter the insects from depositing their eggs. After borers have once entered a tree there is no better remedy known than to cut them out with a knife or other sharp instrument. In the treatment of this insect an ounce of prevention is worth several pounds of cure.

The Flat-Headed Apple-Tree Borer.—The adult of the flat-headed apple-tree borer is a bettle measuring about one-half inch in length, the upper surface of a dark metallic-brown color and the under surface of a coppery bronze color. The larva differs from the round-headed borer in that only a single year is required for its development, pupation occurring in the spring shortly before the appearance of the bettles. It differs, also, in its manner of work, living for the most part just beneath the bark, where it excavates broad, flat, and very irregular channels. Its name, flat-headed borer, is derived from the peculiar flat expansion of the second thoracic segment—which is close to the head. In color it is light yellow and in length measures nearly twice that of the mature insect. This borer attacks diseased or dying trees by preference, inhabits all parts of a tree from the base of the trunk to the limbs, and is not restricted to fruit trees, but attacks a variety of deciduous trees, also.

Infestation may be detected by the discoloration of the bark. A list of the recorded food plants of this borer includes, among orchard trees, apple, pear, and peach. When the borers have entered the tree, they may be destroyed by cutting them out or by killing them in their burrows with a pointed wire, if they were not too deep or too far from the point of entrance.

The best wash for borers, all considered, is made by the union of all the ingredients in the following way: Dissolve as much common washing soda as possible in six gallons of water, then dissolve one gallon of ordinary soft soap in the above and add one pint of crude carbolic acid and thoroughly mix; slake a quantity of lime in four gallons of water so that when it is added to the above, the whole will make a thick white-wash; add this to the above and mix thoroughly, and finally add one-half pound of paris green or one-fourth pound of powdered white arsenic and mix it thoroughly in the above. The remedies advised for the round-headed borer are also of value and are generally employed against the present species. It is necessary, however, that deterrent coverings and washes should be applied farther up the trunk and to as many branches as can be conveniently reached. Careful, clean methods of orchard management are essential as a measure of protection, and involve the cutting out of dead, dying, and injured deciduous forest and shade as well as orchard trees known to be chosen as food by this species.—(Ga. Bul. 44; Mo. Exp. Sta. 14; Bul. 47 Ariz. Exp. Sta.)

*The Fruit-Tree Bark Beetle.**—Injury to the peach by the fruit-tree bark-beetle is usually first indicated by the exudation of gum from the trunk and branches, forming numerous globules, and later by the presence in the bark of numerous small round holes, as if the tree had been peppered with shot. As a rule, only trees in a weakened or sickly condition are attacked, but injury to apparently healthy trees has been observed. The insect causing this trouble is a small cylindrical beetle, about one-tenth of an inch in length, and about one-third as wide. Closely examined, it is seen to be uniformly black in color, except a portion of the legs and the tips of the wing covers, which are dull red.

In this country the fruit-tree bark-beetle attacks various varieties of the plum, cherry, apricot, nectarine, peach, apple, pear, and quince.

The adult insects perish each fall, the winter being passed by the larvæ within the infested tree; and these transform to adults which emerge from the tree usually about the latter part of March. The adult beetles make minute holes through the bark, and they and their larvæ mine or burrow just beneath the bark thus destroying the cambium layer and killing the limb above. While the fruit-tree bark-beetle is almost sure to attack first of all unhealthy, injured or dying trees or parts of trees, they will attack and injure apparently perfectly healthy trees. This bark-beetle is much more difficult to control than other fruit-tree borers, but may be successfully held in check by careful attention to the following: Clean culture is of first importance; every tree or part of a tree that is badly infested or is dying from any cause whatsoever should be removed and burned at once. The trees should be kept in as healthy and vigorous a condition as possible by cultivation and fertilization.

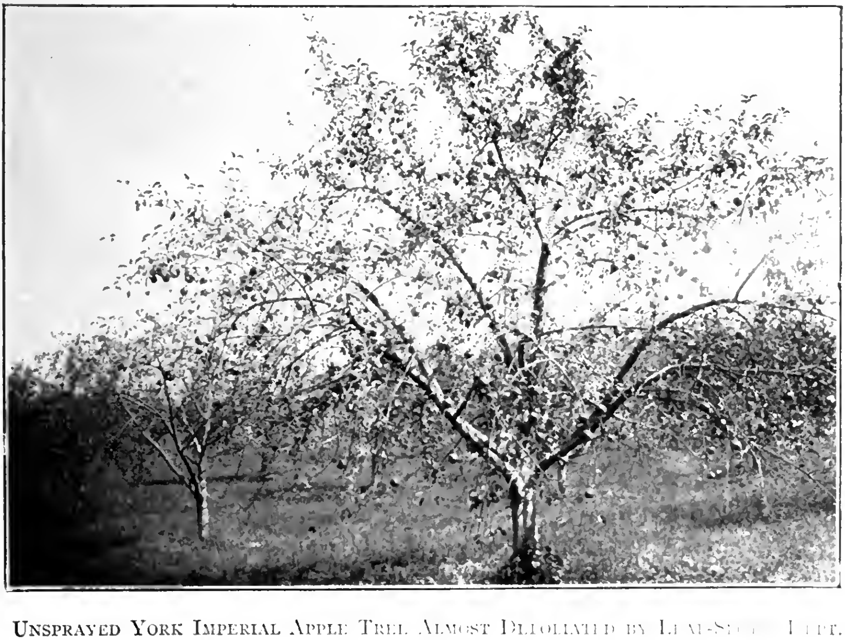
We have found the best wash to be the following: Dissolve as much common washing soda as possible in six gallons of soft water, then dissolve one gallon of ordinary soft soap in the above and add one pint of crude carbolic acid and mix thoroughly; two pounds of lime is then slaked in two gallons of water and filtered so as to remove all dirt and small lumps; this is now added to the above and mixed; while to all is added one-half pound of paris green or one-fourth pound of white arsenic, and thoroughly mixed.—(Bul. 44 Mo. Exp. Sta.; Cir. 29 B. E. U. S. Dept. Agr.; Year Book, U. S. Dept. Agr. 1905.)

The San Jose Scale.†—Probably the most serious single pest to the deciduous fruits in this country is the Pernicious, or San Jose Scale. A tree when badly infested with the San Jose Scale presents a somewhat grayish appearance as if it were coated with ashes, but to the ordinary observer the tree would hardly seem to be infested unless very closely examined. However, if one should attempt to scrape the bark it would be seen to be covered with numer-

* For illustration, see page 447.

† For illustrations, see pages 69 and 501.

Cherry Tree with Leaf-Spot Disease Sprayed with Self-Boiled Lime-Sulphur Mixture. Dept. of Agr.



Unsprayed York Imperial Apple Tree Almost Defoliated by Leaf-Spot. Dept. of Agr.

ous little scales of varying sizes, beneath which lies the small, oval, orange colored, jelly-like objects which are the true insects.

If an adult female insect is closely examined, a small grayish circular scale about one-twenty-fourth of an inch in diameter, the center of which is convex forming a slight nipple will be seen; also numerous concentric circles can be seen around the nipple the scale developing by additions to the outer edge. The scale of the male is somewhat elongated. Beneath the scale is the true jelly-like individual. The color of the scale is variable. In the half mature insect the scale is nearly black with a central gray nipple and one or two grayish rings, but it gradually becomes entirely grayish when approaching the adult state.

The San Jose scale passes the winter in an immature condition fixed to the bark of the host plant, the small, dark-gray or blackish scales being just discernible with the unaided eye. As has been already stated the San Jose scale, in the absence of proper treatment, will quickly bring about the death of most plants of economic importance. When safety, cost and efficiency are all considered, we believe lime-sulphur is the best remedy for the orchardist to use. It can be used very liberally with little or no danger to the trees and, by its color, indicates within a few hours whether the spraying was thoroughly done.

No particular difference has been observed in the effectiveness of the lime-sulphur wash, whether applied in the fall or early spring, during the dormant season. It is believed, however, that early spring is the best time to spray, as the mixture will remain on the trees for a longer period during the summer, when the scale is breeding, and this is desirable. Certain manufacturers have put on the market concentrated solutions of lime-sulphur wash, which have only to be diluted with water for use. These commercial washes have proved to be about as effective in controlling the scale as the well-cooked lime-sulphur wash, and, although somewhat more expensive, have been adopted by many commercial orchardists in preference to the home-prepared spray.—(Pop. Ed. Bul. 193 and 194, N. Y. Agr. Exp. Sta.; Bul. 148, Md. Exp. Sta.; Cir. 129, B. of E., U. S. Dept. Agr.; Cir. 64, Ohio Agr. Exp. Sta.; Press Bul. 48, Col. Agr. E. S.)

*The Oyster Shell Scale.**—This insect has received the common name "oyster-shell scale," owing to the resemblance of its scale or covering to a long, narrow oyster shell. The adult female scales are about one-eighth of an inch in length, usually brown to dark brown in color, though occasionally they have a grayish appearance which is due to bleaching over winter. On account of its size, the scale is not conspicuous unless in large numbers. The scale adheres very closely to the bark of the tree, and resembles it very much in color. During the winter, it shelters the eggs.

A cheap and very satisfactory remedy for the oyster-shell bark-louse is kerosene emulsion, applied shortly after the emergence of the young. This is about May 1st for latitude corresponding to Washington, D. C.

* See illustration on page 375.

Kerosene emulsion stock solution, 66 per cent oil, is made after the following formula:

Kerosene (coal oil, lamp oil) .... 2 gallons.
Whale-oil or laundry soap (or 1 quart soft soap). ½ pound.
Water .... 1 gallon.

The soap should first be dissolved in boiling water; then remove vessel from the fire. Immediately add the kerosene, and thoroughly agitate the mixture until a creamy solution results. The stock emulsion may be more conveniently made by pouring the mixture into the tank of a spray pump, and pumping the liquid through the nozzle back into the tank for some minutes. The stock solution, if well made, will keep for some months, and is to be diluted before using. In order to make a 10 per cent spray (the strength for trees in foliage) add to each 1 gallon of the stock solution about 5 2/3 gallons of water.—(U. S. Dep. Agr. B. E. Cir. 12; B. 64 Del. E. S.; Tenn. E. S. Vol. X.)

The Scurfy Scale.—The female scales are somewhat irregularly oval or pear-shaped in outline, whitish in color and measure about ⅛ of an inch in length. These scales may occur singly or in considerable numbers, forming irregular patches in which case the shape of the individual scales is not readily made out. It is from these scurf-like patches that the insect derives its popular name. Like the oyster-shell bark-louse the winter is passed in the egg stage. The scurfy scale, while infesting a considerable number of plants, is a less general feeder than is the preceding species. It occurs principally upon rosaceous plants, such as the apple, peach, pear, plum, cherry, etc., and also on currant and gooseberry among cultivated plants, but seldom becomes so abundant as to cause particular injury or to require specific treatment. Inasmuch as the life-history of this species is quite similar to that of the oyster-shell bark-louse the treatment for the latter species is equally applicable to this. The point to be remembered is to keep a close watch to see when the young begin to appear and then to spray within a few days, before they have had time to form scales which would protect them.—(Bul. 64 Del. Exp. Sta.; Cir. 121 B. of E. U. S. Dept. Agr.)

The Codling Moth.—This is the parent of the worm which causes the wormy apple. The average adult has an expanse of wing of about three-quarters of an inch. The general color of the front wings is dark gray and of the hind wings light brown. Out near the tip of each front wing, as the photograph shows, there is a well marked brown patch which shows golden when the light falls on it. The fact that the moth closely resembles the bark of the tree in its coloring and being nocturnal in its habits, is, no doubt, why so few fruit-growers become familiar with the adult insect. The moth itself is harmless to the fruit.

It passes the winter as a larva (worm) in a cocoon in any good hiding place, such as under the loose bark on trees. These larvæ begin to transform into pupæ, and soon after the apple blossoms have fallen the moths begin to emerge. The eggs laid by these are placed chiefly on the leaves, and require on an average 9 or 10 days to hatch. Usually it is about 3 weeks after the blossoms fall before the earliest eggs have hatched. On hatching the young larvæ seek an easy place to enter the apple. This the calyx furnishes, and 75 per cent or more of these first brood larvæ enter the fruit by this part.

The best spray mixture to use is 2 lbs. of arsenate of lead to 40 gals. of Bordeaux mixture, or dilute commercial lime-sulphur. The Bordeaux or lime-sulphur is added to control the scab fungus, as this is the most important time to spray for this disease. The Bordeaux need not be stronger than the 3.3.40 formula, and the lime-sulphur may be diluted 1 gal. to 40 gals. Paris green or arsenite of lime may be used with Bordeaux mixture instead of arsenate of lead, but with lime-sulphur arsenate of lead is the only arsenical poison that is safe.

Two methods of control, differing in the kind of spray used, are general; one is known as the Western, the other the Eastern method.

By the Western method spray your trees with arsenate of lead, using one pound to fifty gallons of water. Begin to spray when 80 per cent. of the blossoms have fallen, and have enough outfits on hand to be through in eight days. Use Bordeaux nozzles only, because they throw a coarse penetrating stream, and do not use more nozzles than the capacity of your pump will supply and still keep the pressure up. Set the nozzles at an angle of 45 degrees by means of an elbow coupling. Throw the spray directly into the throat of every flower.

To reach the bottom of the flowers much pressure is absolutely necessary. Do not spray at less than 80 pounds, and if possible use 200 pounds or more.

By the Eastern method use arsenate of lead of any good brand at a strength of one and a half to two pounds of the arsenate to fifty gallons of water is preferable. The time to apply the first spray is determined by the condition of the calyx of the bloom. This time is following the dropping of the petals but before the closing of the calyx. A period not to exceed from five to seven days for any one variety would cover the time when this first spraying should be done. Use a nozzle that gives a fine mist such as the Friend or Mistry, Jr. Under cultural methods we include not only cultivation, but also keeping the dead scales of bark scraped off the trees, pruning, and burning the rubbish which naturally accumulates in the orchard, keeping fallen apples picked up and either used or destroyed.—(Press Bul. 42, Col. Exp. Sta.; Bul. 65, N. Mex. Exp. Sta.; Bul. 142, Md. Exp. Sta.; Bul. 187, Ont. Dept. Agr.; Bul. 142, Cornell Exp. Sta.; Pop. Bul. 30, Washington Exp. Sta.)

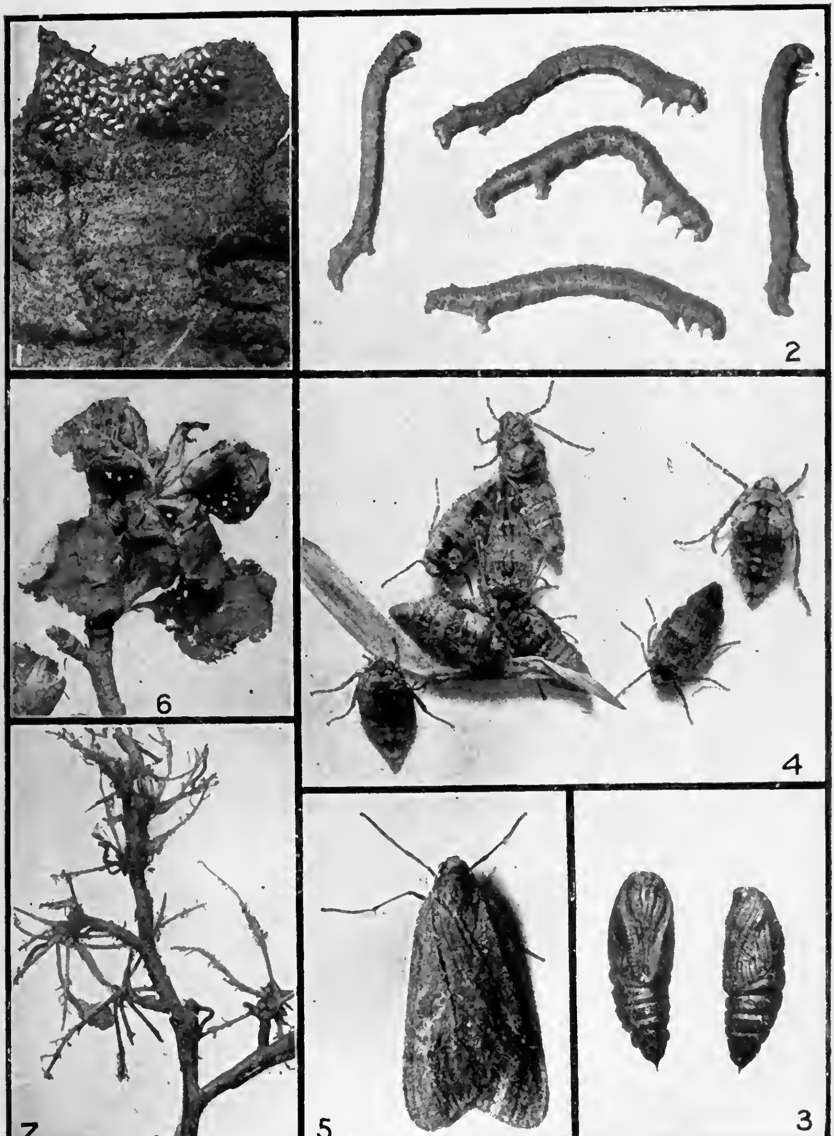
The Apple Maggot or Railroad Worm.—The parent insect that lays the egg from which the railroad worm hatches is a two-winged fly, about the size of the common house fly. It looks much like the house fly except that its wings have dark zig-zag marks on them. The railroad worm is hatched from an egg laid beneath the skin of the fruit. From July to October is the time of year to fight the apple maggot or railroad worm. The way to do this is to keep the infested apple from rotting beneath the trees. This can be accomplished either by picking up the drops every few days, or by maintaining enough livestock beneath infested trees to keep the drops cleaned up.

The Apple Red Bug.—The adult Red Bug is about 1/4 inch long. The general color varies from red to nearly black; usually the thorax is black in front and red behind. The wings are red, usually black along the inner edge and with a pointed ovate black spot near the outer margin. The principal injury is caused by the punctures in the young fruit. The apples are then very small and the four sharp bristles of the bug's back penetrate quite to the center. The results of our experiments show that the young nymphs may be killed by an application of Black-leaf tobacco extract diluted 1 to 65, or Black-leaf 40 diluted 1 to 800—that is, about 1 ounce in 6 gallons of water or 1/2 pint in a barrel of 50 gallons. The efficiency of this spray is increased by the addition of about 2 pounds of soap to each 50 gallons. The majority of the eggs of the Red Bug hatch after the opening of the leaves of the fruit buds and before the blossoms open. The first application should be made just before the blossoms open and while the nymphs are small, soft, and tender.—(Bul. 101, B. of E. U. S. Dept. Agr.; Cir. 14, New Hamp. Exp. Sta.; Bul. 291, Cornell Exp. Sta.)

Plum Curculio.—This pest infests the apple, causing a great many knotty apples. (For description see the *Plum* Insects.)

The Apple Plant Louse.—The insects appear with the foliage, and where they are at all numerous the leaves begin to curl, and growth is checked in early summer. The aphids excrete a sweet, sticky liquid. The females are of a uniform velvety green, sluggish in motion, and rather more than one-twentieth of an inch in length. The males are smaller, much more active, and dull yellowish-green in color. The eggs are large in proportion to the insects, dark-green in color when laid, becoming black in two or three days. They are regular, rather elongate-oval in shape, and smooth, shining. The apple plant louse hatches from the egg as soon as the buds begin to develop in early spring. In about fifteen days a stem-mother becomes developed and begins to reproduce. Spray with Black Leaf 1-65, or Black Leaf 401-840, or 10% Kerosene Emulsion.—Bul. 193, N. J. Exp. Sta.)

The Canker Worm.—Two species of canker-worms in the United States, the spring canker-worm and the fall canker-worm, are often very troublesome pests in apple orchards, infesting also the elm, cherry, and to a less degree, a few other trees. The life history and habits of the fall canker-worm practically parallel those of the spring species. The females of both species are wingless, hence their dissemination is very slow. These canker-worms are green or brown, more or less striped with longitudinal lines. Just back of the head are six legs with pointed claws, and near the posterior end of the body are four or six other legs, different in form. When the caterpillar crawls the middle of the body assumes the shape of a hump or loop; on account of this these insects are called looping caterpillars or measuring worms.



WORK OF CANKER-WORM: 1. EGG MASS ON BARK; 2. LARVAE; 3. PUPAE; 4. FEMALE MOTHS; 5. MALE MOTHS; 6. WORK OF CANKER-WORM ON APPLE LEAVES WHEN SMALL; 7. LATER WORK. (FIGURES 1 TO 5 ENLARGED; 6 AND 7 REDUCED.) DEPT. OF AGR.

Orchardists having canker-worms to contend with may confidently expect to practically eradicate them in the course of one or two seasons by following the methods above described, namely, thoroughly spraying the trees with a strong arsenical and thoroughly plowing the ground during the summer. If Paris green is used, this should be applied at the rate of 1 pound for each 100 gallons of water, and unless used in Bordeaux mixture there should always be added the milk of lime made from slaking 4 or 5 pounds of good stone lime. Arsenate of lead may be used at the rate of 6 to 10 pounds to 100 gallons of water or Bordeaux mixture, and because of the strength at which it may be used without injury to foliage and its excellent sticking qualities it is to be preferred to other arsenicals for canker-worms. Another important method of protecting high orchard and other trees which it is impracticable to spray is the employment of special protectors, such as bands of cotton, or sticky substances.—(Bul. 68 Part II, U. S. D. A. B. E.; Bul. 44, New Hamp. Agr. Exp. Sta.)

The Apple-Tree Tent Caterpillars.—These are dull reddish-brown, stout-bodied moths, with a wing expanse in the females of about 1.5 to 2 inches, and in the males of from 1.2 to 1.3 inches. Obliquely across the forewings of each sex are two nearly parallel whitish lines, as shown in the illustration. The conspicuous and unsightly nests or tents of this insect are familiar objects in the spring. The caterpillars feed upon foliage of the trees, stripping the leaves from the limbs adjacent to the nest.

The favorite food of the tent caterpillar is the wild cherry, and this is probably its native food plant. Next to the wild cherry the apple is apparently preferred. In the absence of its favorite food, or under special conditions, it attacks many other plants, as plum, peach, thorn, pear, rose, and other members of this group; also beech, witch-hazel, elm, maple, various species of willows, oaks, and poplars, etc. Eggs are deposited in masses or belts encircling the smaller twigs.

The unsightly nests are especially apt to be found on wild cherry, apple, and other trees growing along roadsides, fences, and elsewhere. In most cases such trees could doubtless be removed without disadvantage, and their removal would greatly reduce the numbers of this pest by lessening their favorite food supply. Tent caterpillars are readily destroyed by arsenicals sprayed on foliage of trees infested by them. The caterpillars are killed in from two to three days by the use of Paris green at the rate of 1 pound to 300 or 400 gallons of water. Orchards or trees sprayed with arsenicals in the spring for the codling moth, canker-worms, or similar insects will be kept practically free from tent caterpillars.—(Cir. 98 U. S. D. A. B. E.)

The Fall Web-worm.—The common Fall Web-worm is so named because of the web which it spins over its food plant in August and September, somewhat resembling that made by the Tent Caterpillar in the spring, with which it is often confused. The moths are of a pure white color, the wings expanding an inch to an inch and a quarter. This species is practically the only common moth which might be mistaken for the Brown-tail Moth, which is also pure white except the bushy brown tail, while the body of the fall web-worm moth is white. Rarely, however, the fall web-worm moths have the wings spotted more or less with black. The young caterpillars, which seem to be almost all head and hair, at once commence to spin their web over the foliage upon which they are feeding. Within this web the colony from an egg mass feeds, enlarging it as it becomes necessary. The webs are usually started at the tips of limbs and are to be first noticed about August 1st. When the food in the webs become scarce the older caterpillars scatter over the tree where food is more abundant, and as soon as full grown seek a place in which to spin their cocoons. The full grown caterpillars are about an inch long and quite woolly, being thickly covered with long white and black hairs, which project from numerous prominent black tubercles.

When the caterpillars are first noticed at work on the tips of the twigs, if they seem to be abundant, it is best to spray the tree with an arsenical. Arsenate of lead, five pounds to the barrel of water, is best, though Paris green, at the rate of one pound to 100 gallons, with a pound or two of freshly slacked stone lime is equally effective, but does not adhere as well. It is useless to wait until the tree is covered with large webs and then spray. To be effective the tree must be sprayed early in August soon after the eggs hatch. As it is also advisable to spray at this time for the young brown-tail moth caterpillars, it will be found to be good practice to spray about this time every year.

The Yellow-Necked Apple Caterpillar.—During August one often notices the tips of the apple limbs defoliated for a foot or two. If examined for the cause of the damage either the Yellow-necked Apple Caterpillars or the next species to be described, the Red-humped Apple Caterpillars are found huddled together as if confessedly guilty. The larvæ become full grown during the latter half of August, five or six weeks after hatching from the eggs. The caterpillar is then about two inches long with jet black head, and the next segment, often termed the neck, a bright orange yellow, from which the insect is named. Down the middle of the back runs a black stripe, and on either side of the body are three stripes of black alternating with four of yellow, the body being thinly clothed with long, soft, white hairs. The caterpillars feed together in colonies and are often found clustered together on a limb in a solid mass. If the limb bearing it is jarred or if a caterpillar is touched, it at once assumes a position characteristic of this genus, throwing the head and tail in the air with a jerk and clinging to the limb by the abdominal prolegs.—(Bul. 139, New Hamp. Exp. Sta.)

The Red-Humped Apple Caterpillar.—With much the same habits and manner of injury as the last species and often associated with it, is the Red-humped Apple Caterpillar. The name is given on account of the prominent hump on the fourth segment, which, with the head, is a bright coral red. The body of the full grown caterpillar is striped with yellowish-white, and dark brown or black lines and a double row of black spines extends along the back. The back is marked with five narrow black lines. The full grown caterpillar is about an inch and a quarter long and tapers toward the posterior end which is usually held in the air. The caterpillars appear about the same time in August and defoliate the limb from the tip inward the same as the Yellow-necked Apple Caterpillar.

These caterpillars are also gregarious and are often found huddled together in masses on the limbs. When handled a caterpillar will emit a fluid which has a peculiar acid smell and which doubtless serves as a defense against its enemies. The caterpillars also feed on plum, rose, thorn, pear, cherry, willow, blackberry, and other related plants.

As the work of these caterpillars is very quickly noticed and as they habitually feed together in colonies, it is an easy matter to hand pick and destroy them, or swab them off the limbs with a rag or waste saturated with kerosene. When a colony is noticed at the tip of a limb it may be cut off and burned, though this is rarely necessary. If this and other caterpillars are common upon the terminals it will be well to spray the trees about August 1st with arsenate of lead, three to five pounds per barrel. To be most effective this should be applied while the caterpillars are still small.

The White-Marked Tussock Moth.—This caterpillar is recognizable by its bright red head and by the velvety black back, on which there are four thick tufts of creamy colored hair, looking like round paint brushes. At either end is a pair of long, black, plume-like hair pencils and there are shorter tufts of hair along the sides. In general, the caterpillars give the impression of being yellow, with black and bright red markings. In the winter the eggs may be easily removed and destroyed while pruning the trees. Where apple orchards have been sprayed with an arsenical, such as Paris green or arsenate of lead late in May, in the usual manner for the codling moth and diseases, there will be little trouble with the first brood, and probably but few of the second. Should the second brood appear numerous spraying about August 1st, as for the other apple caterpillars described, will destroy them.

Summary.—The fall web-worms, yellow-necked apple caterpillars, red-humped apple caterpillars, tussock moth caterpillars, and hickory tiger moth caterpillars injure apple foliage in late summer. They may be controlled by spraying with an arsenical insecticide about August first. As it is also desirable to spray for the brown-tail moth at this time, an early August spraying may well be made a regular orchard practice, for which directions are given herein.—(Bul. 139, N. H. Exp. Sta.; Bul. N. J. E. S.)

Green Fruit-Worms.—From time to time, green worms, about the size of cut-worms, are to be seen working on fruits. The writer has usually found them on apples and once on strawberry. They are apple-green or light-green in color and have three light-yellowish stripes running the entire length, one line on the back and one on each side. Sometimes there are additional markings which are quite variable. They eat holes in the young fruit and foliage. They are said to work on a number of trees and shrubs, including most of the fruits grown in Michigan, feeding during the day and probably also during the night, and dropping to the ground when disturbed. The pupal stage is passed in earthen cells in the ground. Professor Slingerland, who discusses these creatures at length, says that the insects are very difficult to kill with the ordinary late sprays, but that trees sprayed before they blossom, with the arsenites and bordeaux are apt to be pretty free from them. As the insects are periodic in their invasions, often disappearing for a number of years together, it is not possible to foretell just when such a spray will be necessary. Those who apply bordeaux before the buds open, as a regular practice, may find it a paying investment to add a little poison for this insect, the bud-moth, and several other pests. Professor Slingerland also recommends jarring in the same manner as for curculio.

*The Cigar Case-Bearer.**—This very interesting little creature is occasionally so numerous as to cause injury to apple and pear. The larva makes a case in a manner similar to the resplendent shield-bearer. This little case resembles a minute cigar about one-fourth of an inch long. It is very carefully described by Professor Slingerland in Bulletin No. 93 of the Cornell University Experiment Station. The larva is said to make two cases during its lifetime, one in the fall, curved and very small, and one in the spring in which the pupal stage is passed. It attacks the buds as they swell, and later feeds on fruit and foliage reaching out from the case and mining under the skin of the leaf. The adult is said to be steel grey in color and spreads less than half an inch from tip to tip of its wings. It may be controlled by early sprays of paris green, applied when the buds open, and also at the time when the trees are sprayed for the codling moth. Usually it will be found expedient to add the poison when spraying with Bordeaux for the scab, thus reducing the expense.—(Bul. 24 Mich. Agr. Exp. Sta.)

The Pistol Case-Bearer.—This insect is a moth of a general dark drab color. The larva is the destructive form and lives within a case. The cases are of a dark brown or black color, more or less covered with grayish pubescence from the leaves. Their form is aptly described by the word pistol-shaped. A careful examination of one of these moving pistol-shaped objects will reveal its inhabitant, an orange-colored, black-headed caterpillar about one-fourth of an inch in length. Thus the insect has quite a wide range of food-plants, including three orchard fruits, apple, cherry, plum, and probably the chestnut. Beginning on the swelling buds, the case-bearers continue their destructive work on the opening leaves and flowers, showing a decided preference for the flowers.

The pest can be controlled by spraying twice before the buds open with 1 lb. Paris green to 200 gals. of water or a fungicidal solution.

The Palmer-Worm.—This pest does all of its destructive work in the caterpillar stage of its life. Even when full grown, this

* See illustration on page 637.

Work of Trumpet Leaf-Miner of Apples; Larvae Broods in Apple Leaf.
Dept. of Agr.

palmer-worm is quite a small, slender caterpillar, measuring only about half an inch in length. It general color is olivaceous or brownish-green, lighter on the underside, and usually with a light-brown head. The body is striped with 4 narrow white lines. The palmer-worm moth is a minute gray or brownish-gray insect measuring across its expanded wings only a little more than ½ inch. This insect appears at irregular intervals in great numbers, doing considerable damage in the territory where it occurs. It feeds on apple, plum, cherry, and oak.

The codling moth sprays will keep the insects in check on apple and the annual poison sprays on plum and cherry for curculios will answer on those trees.—(Bul. 124 and 187 Cornell Exp. Sta.)

Apple Leaf-Miner.—Many fruit-growers have observed small, brownish patches on the leaves of apple trees. These patches are caused by a minute insect which feeds on the internal tissue of the leaf. The insect is the larva of a small gray moth. The mines are sometimes so numerous that as they increase in size they run together and form one large blotch covering the greater part of the leaf. As the epidermis of the upper surface of the leaf dies it loses its elasticity, and a curling of the leaf inward is the result. The leaves at this stage cease to perform their functions and soon drop. The higher branches of the tree are usually more seriously affected and lose their foliage first. This loss of foliage results in premature, undersized fruit. By checking its vegetative activity the vitality of the tree will also be more or less reduced. In view of the fact that the insect feeds entirely on the inner tissues of the leaf, the application of arsenicals or contract insecticides is useless for the control of this pest. The gathering up and destroying of the leaves in the fall readily suggests itself, and is recommended where tillage is not practiced. There are, however, so many insects of various species which spend part of their existence in the ground and which are destroyed by breaking up their quarters, that, aside from the generally recognized benefits, orchard tillage is, in most cases, recommended.

The Bud-Moth.—Early in the spring, just as they commence to swell and open, the buds of apple and pear and sometimes those of plum, cherry, quince, and peach trees, are occasionally attacked by small, almost naked caterpillars, about a fifth of an inch long, and dirty white in color, the head and thoracic shield being black or very dark brown. The caterpillars feed on the opening buds, later binding the young leaves and blossoms together with silken threads. Inside the nest thus formed, the larvæ feed and attain the length of nearly three-fourths of an inch, change to pupæ and finally to adult, winged moths, which usually emerge here during the last of June, or first part of July. The eggs are soon laid and the larvæ hatched, the young larvæ feeding on the under side of the leaves and skeletonizing them. When partially grown, they spin small nests or hibernaculi, in protected places, and remain until the following spring, when they attack the buds as described.

The best remedy is to spray with arsenicals just as the buds open. Cover the buds with poison, and the young larvæ will be killed early in their career. Sometimes more than one application is necessary, but be sure to hit each bud with the spray. The presence or absence of the little nests later will indicate the success or failure of the application.—(Bul. 45 Conn. Exp. Sta.; Bul. 24 Mich. Agr. Exp. Sta.)

The Buffalo Tree-Hopper.—A small green insect, three-eighths of an inch in length, triangular in form, and shaped somewhat like a beechnut, but having the prothorax extending above the head in two horn-like growths. They sometimes weaken the twigs of apple by laying their eggs therein. The wounds so made are slow to heal, and on young trees may be the cause of injury through the breaking off of the twigs. No remedy is known except the cutting out of the eggs during the fall and winter.—(Bul. 24 Mich. Agr. Exp. Sta.)

The Plum Curculio.—(See Plum Insects).

PEAR INSECTS.

The European Pear Scale.—This pest, which is commonly known in California as the Italian pear scale, closely resembles to the naked eye the San Jose scale (*Aspidiotus perniciosus* Comst.), but can be readily distinguished from this species by the form of the male scale which is a great deal longer and carinated. Furthermore they can be separated by the manner of working. The European pear scale, in California, probably works only under cover of the lichens on the trunk and larger limbs, and apparently does not work on the twigs or younger branches as does the San Jose scale.

Distillate-oil emulsion at 6 per cent strength and crude-oil emulsion at 12 per cent strength, measured by their efficiency against scales and lichens, convenience of preparation and application, and cost, are the sprays best adapted for the European pear scale. All sprays, to insure the best results, should be applied with a power outfit at a high pressure (180 to 200 pounds). A coarse, drenching spray applied with crook nozzles is preferable, and February is the best month in which to spray.

The Howard Scale.—Individual insects are of very minute size, being smaller than a pin head. They are of yellowish-orange color, covered by a pale grayish scale secretion. For the greater part of the insect's life it is motionless upon the bark or fruit. The winter is passed in an immature stage. In the spring, winged males appear, and early in the summer young insects are hatched from eggs laid beneath the female scale covering. These crawl about for a short time, finally settling down, the females to remain motionless for the rest of their lives.

Slightly infested trees will exhibit only inconspicuous grayish dots. Badly infested trees have a grayish appearance over their bark, much as if a layer of ashes covered the tree. When rubbed, this gives the surface a greasy or buttery appearance, caused by the crushing of the bodies of myriads of the yellow parasites hidden under the scales. It is most common upon pear, prune, plum, and almond. The Bartlett is the most susceptible variety of pear grown in the Grand Valley.

The lime and sulphur sprays prove to be superior from the standpoint of effectiveness and cost. They are to be recommended to the use of fruit growers as the most valuable spring spray for trees still dormant. Besides being a contact insecticide of high value against other fruit tree insects, it is also valuable as a fungicide.—(Bul. 80, Part VIII, B. of E. U. S. Dept. Agr.; Bul. 30 Col. Agr. Exp. Sta.)

*The Pear Thrips.**—Injury to the various fruit trees by this species is caused by the feeding of the adults on the developing buds and early blossoms, by deposition of eggs into the fruit stems, leaf stems, and newly formed fruit, and by the feeding of the larvæ in the blossoms and on the young fruits and foliage. On pears the greater injury is produced by the adults, which often prevent the trees from blooming, while on prunes and cherries the larvæ frequently prevent a crop of fruit from setting after the trees have come into full bloom. Also, the deposition of eggs into the fruit stems of prunes and cherries so weakens the stems that much of the young fruit falls. The feeding injury is not produced by a biting or chewing process. By rasping the tender surfaces in the developing fruit buds and the young fruits with their hardened or chitinous mouthparts, the thrips rupture the skin, causing an exudation of sap which is often followed by more or less fermentaion, especially before blooming. The feeding by larvæ on prunes after blooming causes the well-known thrips "scab," while most of the scarred and misshapen pears are caused by the work of the adults.

The adults or winged form of the thrips first appear on the trees about the middle of February and emergence from the ground continues till early April, maximum emergence, however, occurring in late February and early March. The pear thrips is in some respects an unusual insect in that it remains in a dormant or semidormant condition for about ten months of the year. Although on the trees for only two months out of the twelve, it is able in this short time, in the absence of treatment, to completely destroy all prospects of a crop of fruit, in many cases within a very few days. The trees are attacked at the period of bud swelling and blossoming, when they are most susceptible to injury. These minute insects come literally in swarms, and may, if left alone, completely destroy all of the fruit buds of an orchard in four or five days. Many cases have been known where a delay of four or five days in spraying resulted in loss of the entire crop of fruit, and in some cases half of all the buds were killed in three days after the thrips appeared on the trees in great numbers. In view of this condition it is very evident that any means of control must be very thorough and done in the most exacting manner at the proper time.—(Cir. 131, B. of E. U. S. Dept. of Agr.; Bul. 68, Part I, Revised B. of E. U. S. Dept. Agr.)

Spraying is by far the most common and the most satisfactory means for controlling the pear thrips on all classes of deciduous fruit trees in California. Only the most efficient spray materials should be used, namely, the combination of distillate-oil emulsion and tobacco extract or distillate-oil emulsion and nicotine solutions.

* See illustration on page 339.

The spraying must be thoroughly done and put on the trees when the thrips appear in numbers, not waiting till many buds have been destroyed. It is strongly advised to use power machines, and growers are urged to use them for all the spraying, and to have a tower platform elevated over the tank so that one man can thoroughly drench the tops of the trees. It is absolutely necessary to use high pressure—from 150 to 200 pounds—and only angle nozzles should be employed, and these must be held close to the bud clusters to force the spray directly into the ends of the buds. This is absolutely necessary to secure good penetration and get satisfactory results. Plenty of material—3 to 5 gallons per tree for pears, depending on the size of the tree—should be used; more liquid is required for large prune trees; large cherry trees may require 7 to 8 gallons per tree for satisfactory results.

In badly infested orchards three applications are necessary the first year for controlling the pear thrips. Two of these sprayings should be directed against the adults and one against the larvæ, and to obtain satisfactory results must be timed properly. The first spraying should come as soon as the thrips can be found on the trees in numbers. The second spraying, which is also for adults, should come from four to ten days after the first, depending somewhat on variety of fruit, stage of bud development, and rapidity of emergence of thrips from the ground. On pears this will usually be just as the earliest cluster buds are spreading, and on prunes and cherries when the tips of the petals first begin to show. Both of these applications are important and necessary to insure the production of a good crop of uninjured blossoms. The nozzles should be held close to the bud clusters and the spray directed into the ends of the buds. This makes it necessary that the spraying be done mostly from above. The third spraying is for larvæ and properly comes just as most of the petals are falling from the trees, depending somewhat upon the variety of fruit. Those who can do so successfully are advised to irrigate and plow in the fall. This is to be followed by thorough spraying the following spring.—(Cir. 131 B. of E. U. S. Dept. Agr.)

The Pear Psylla.—Occasionally we hear of trouble arising from the pear psylla, an European insect, which was first noticed in Michigan in 1891. The presence of this insect is usually indicated by a general loss of vitality in the tree, early in the season. The young growth droops, and sometimes considerable foliage and fruit drop from the tree. The leaves are seen to be smeared with honey-dew, which attracts ants and wasps, and which supports a black, sooty fungus later in the season.

The immature insects are very small, a little more than one-sixteenth of an inch in size, yellow at first but afterward becoming marked with black and red. They hatch from the eggs in May and immediately commence sucking the juice of the leaves. The secretion of honey-dew is so copious that the insects soon become surrounded by small puddles of this sticky liquid, in which they sit and grow. In about a month, they change to the adult, winged form, in which stage they are provided with wings, and with strong jumping legs. When disturbed, they jump and fly away, sometimes being so numerous as to appear to fly in droves. Several broods are reared in one season.

Spray with weak kerosene-emulsion while the insects are in the immature condition in late May and early June. At this time they cannot fly. Any of the strong winter washes should prove all right as they pass the winter hidden away in cracks and crannies and under the buds. Clean culture will also prove useful, for judging from allied species, many adults will be found to pass the winter in rubbish.

The Pear-Leaf Blister-Mite.—About the time when the young pear leaves become full grown, and while they are still tender, they sometimes are disfigured by pinkish, thickened patches, involving a portion of the leaf, or occasionally the entire leaf. As the leaf becomes firmer in texture, the patches become darker, finally appearing black and corky. A thin slice through such a thickened, corky patch, shows, under the microscope, a cavity connecting with the outside by a small opening. In the cavity may sometimes be found the cause of the mischief; minute, white mites, elongate in form, and so small that a glass is required in order to be sure of them. These little mites are the cause of the thickened growth or gall, and the consequent injury to the foliage. Sometimes they form galls in the young fruit as well. Oftentimes the foliage falls, and the fruit fails to amount to anything. The mites pass the winter tucked away under the bud scales.

As the mites are concealed, during the growing season, in the galls of the leaves, it is useless to spray during that period. In the winter, however, they may be killed by a spray of strong kerosene-emulsion applied while the buds are dormant, or at any rate before they open in the spring.—(Bul. 24 Mich. E. S.)

The Pear Slug.—The damage to the foliage of the pear, cherry, plum, and allied trees from the slimy slug-worm is familiar to every fruit grower. Two or three generations of these slug-worms, or slugs, as they are also termed, appear during the summer and frequently in such extraordinary numbers, with the later broods, that the leaves of the attacked plants turn brown, die, and fall to the ground in midsummer, and the new growth of foliage which is afterward thrown out is often similarly destroyed. The slug-fly is a small, glossy black insect, considerably less in size than the house fly, measuring only about one-fifth of an inch in length. The wings, which are four in number, are transparent, iridescent, and have a smoky band across the middle, which varies in intensity in different specimens. It belongs to the family commonly termed saw-flies on account of the saw-like instrument or ovipositor with which the female insect places its eggs in the leaves or other soft parts of the plant. At first it is clear or free from slime and in color nearly white, except the yellowish-brown head; but almost immediately the slimy or gluey olive-colored liquid begins to exude over its entire body, giving it the appearance of a minute slug, or soft snail, from which it gets its name. Its head is dark brown, appearing black under the slime, and the body also becomes almost equally dark. The anterior segments are much swollen, covering up and concealing the head and thoracic legs.

As soon as the larva emerges from the egg it begins feeding on the upper surface of the leaf, eating out small holes or patches about the size of a pinhead or smaller, but never eating entirely through the leaf. The larvæ feed almost invariably on the upper side of the leaves and the minute eaten spots which they make at the start rapidly increase in size until much of it, but not the entire surface of the leaf, is denuded, leaving merely a network of veins, or a leaf skeleton, held together by a nearly intact lower epidermis.

The best means of destroying the slug-worm is to spray the plants with an arsenical wash or with a simple soap solution. The larvæ are delicate and easily killed, and as they eat almost exclusively on the upper surface of the leaf where the poison can be most easily placed, they get the greatest amount of it and are the easiest of all larvæ to be thus exterminated. The plants may be sprayed with Paris green or other arsenical wash at the rate of 1 pound of the poison, mixed with an equal amount of lime, to 250 gallons of water. The soap wash to be effective must be applied at a strength of one-half pound of soap to a gallon of water, first dissolving the soap, preferably whale oil, by boiling in a small quantity of water.—(Cir. 26 U. S. D. A. B. E.)

The Codling Moth on Pears.—The pear crop of California suffers much from injury by the codling moth, and in view of the commercial importance of this crop, the losses represent in the aggregate a large item. The injury is especially important on green fruit destined for shipment to eastern markets, but even in the case of drying stock there is without doubt an important deterioration in quality. For description of the insect and its life history see the Codling Moth under Apple Insects.

There are practically two full broods of larvæ in the pear-growing districts of the interior counties of California. Comparatively few of the first-brood larvæ go over the winter. The number of first-brood larvæ being relatively small, the injury is not so noticeable, and many growers overlook the importance of destroying this brood of worms to prevent the greater damage by the more important second-brood larvæ, which begin to enter the fruit just prior to the first picking. The first-brood larvæ begin entering the fruit about a month after most of the petals have fallen, though this time may vary somewhat with the season. All spraying for the first brood should be done within three to four weeks after the blossoms are off the trees.

Two, and preferably three, treatments are advised, using arsenate of lead at the rate of 4 pounds to each 100 gallons of water. The first application should be made as soon as most of the petals have fallen, and especial pains should be taken as nearly as possible to fill each calyx cup with the poison. The trees should be drenched. The second treatment should come three to five weeks after the falling of the petals. The third application should be given nine or ten weeks after the falling of the blossoms, or about two weeks before the first picking begins. If only two treatments can be given, the first and second of the above schedule should be given. See the Apple Insects.—(U. S. D. A., B. E. Bul. 97, part II.)

QUINCE INSECTS.

A Quince Mealy-Bug.—A quince orchard near Geneva was found to be infested, early in April, with numbers of little plant-louse-like bugs. Nearly all of the trees showed some of the tiny, powder-covered, soft-bodied, wingless bugs; but none of them were so infested as to be perceptibly injured. These bugs are quite similar in structure and feeding habits to the plant lice; but unlike the lice, they are produced from eggs, and their mature form is not unlike that first hatched, except that the larvæ at first are pink in color, while the adults are white from their covering of powder. The eggs are laid along in late June and early July, and are placed in a double-walled cocoon of silk.

As these bugs are soft bodied and live openly on the twigs during spring and early summer, they can easily be controlled by spraying with whale-oil soap solution, 1 to 5. The arsenites would have no effect, as, like all bugs, these meal-coated ones draw their food from beneath the surface. Where there is loose bark, scraping the trunks and branches to uncover the insects and egg cocoons, and painting the wood in winter with strong whale-oil-soap solution will be of benefit.—(Bul. 24 Mich. Agr. Exp. Sta.)

The Quince Curculio.—Like all beetles, this quince curculio passes through four different stages during its life—the egg, larva or grub, pupa, and the adult or beetle. It is injurious to the quince in two of its stages. The beetles sting the fruits, forming many of the familiar knotty places, and wormy quinces are the work of the grubs or larvæ. Quince growers should thus familiarize themselves with these two stages of the insect. The other stages—the egg and pupa—are discussed later on in connection with the story of the life of the pest. The beetle is somewhat larger than the common plum curculio, has a comparatively longer snout, and is very broad-shouldered. Its general color is of a rather uniform brownish gray, mottled more or less with white, especially on the thorax.

The larva is a fleshy, maggot-like, footless grub of a semi-transparent, light flesh color. Its head is dark brown, with the horny jaws darker, and there is a lighter brown, shield-like area on the back of the first thoracic segment. The long dreary months are spent by the grub in a little earthen cavity or cell two or three inches below the surface. After leaving the fruit in the fall, the grub burrows its way into the soil and there forms its winter home by rolling and twisting its body around and thus packing the earth back, leaving a small, oval, smooth-walled cell in which its winter nap is undisturbed by the elements above.

With the warmth of the spring-time the grubs begin their destined transformations necessary to complete their life cycle. Wonderful changes take place beneath the grub's skin which is finally cast off and a form, quite unlike the grub, known as the pupa appears. From 10 to 20 days are spent by this insect in the spring in this quiescent pupa stage in its earthen cell. Finally the pupal shroud or skin is cast off and the active adult or curculio appears.

For a week or more after they emerge from the ground in the spring, the curculios feed upon the growing quince fruits, and possibly to a slight extent upon the leaves. After feeding on the fruit for about a week, as described above, the beetles copulate and soon begin laying eggs. The eggs hatch in from seven to ten days, and the little grubs at once begin eating their way into the fruit. The grubs continue feeding in the fleshy part of the fruit for about a month, forming therein a large worm-eaten cavity.

With our present knowledge of its life and habits, the jarring process is the most successful method for fighting the quince curculio yet suggested and tested. Those who practice the jarring method successfully, jar the trees every day, if possible, from the time the beetles appear until their numbers decrease beyond the danger point, or only a few are captured each time. This jarring process involves considerable labor and expense, but experienced fruit growers tell us it costs only from 15 to 20 cents to jar a tree during the season. One should consider that this slight expenditure may often favorably decide the important question of a large crop of fine fruit or a meager crop of knotty and wormy fruit. The insects of the quince are practically the same as those of the apple.—(Bul. 148 Cornell Agr. Exp. Sta.)

PEACH INSECTS.

The Black Peach Aphis.—The black peach aphis infests the roots, tender shoots, and foliage of the peach, causing more serious injury when occurring on the roots. Its presence on the roots is often unsuspected, the failure of the trees being attributed to other causes. Young trees recently planted are most subject to injury, before they have become well established in the soil. Infested trees may fail to grow off well, at the end of two or three years being scarcely larger than when planted. The foliage assumes a yellowish green, sickly appearance, the leaves becoming somewhat curled on the edges and blotched with red, suggesting a wet soil or incipient yellows.

The insects occur in two forms—winged and wingless—the former occurring only on the shoots and leaves, while the latter occur on both the foliage and roots. An individual aphis is quite small, the body in both forms averaging about 2 mm. in length, shining jet black or dark brown in color, oval in shape, though the body of the wingless form is stouter. The young are faint greenish-brown in color, gradually becoming darker as they grow, till the jet black condition of the adult is reached. They feed by means of a beak, which is thrust into the tissues of the plant, and the sap removed by their combined attack constitutes a serious drain on plant vitality. The insect lives on the roots of the plant during the entire season, and breeding is continuous, except during the winter, which is spent in hibernation. The aphides are usually attended by ants, which aid them in securing food, transporting them from place to place and otherwise caring for them. In the spring the aphides make their way above the ground and begin to feed and breed on the tender

Cultivating and Spraying at Hillcrest Orchards, Kentville, N. S. Dept. of Agr.

growth just pushing out. During summer the aphides for the most part are to be found on the roots, though a few may be found on the foliage and shoots in badly infested orchards at almost any time during the growing season. Below ground they occur more or less promiscuously on roots of all sizes, but the smaller and more tender ones are preferred. Some of the aphides may retain their hold on the roots after the trees are dug, and the insect is thus frequently distributed on nursery stock.

Heavy dressings of kainit, according to Dr. J. B. Smith, are effectual in killing the aphides. The fertilizer should be applied over the ground covering the root area of the tree, preferably just before a rain. Unleached wood ashes, from one-half to one bushel per tree, is recommended by Pettit as being very effective. It is better to first remove the soil over approximately the root area of the tree, replacing it after the ashes have been applied. Ground tobacco dust may be used in the same way. In all of these substances the insecticidal properties leach out, coming in contact with the soft bodies of the aphides on the roots and thus killing many of them. Aerial forms may be killed by "Black Leaf" 1-60.—(Year Book 1905, Dept. Agr., "The Principal Insect Enemies of the Peach.")

The West Indian Peach Scale.—The female scale is 2 to 2.5 mm. or .08 to .10 inches in diameter, quite convex and usually grayish white in color. The scales are often inconspicuous from being covered with a thin layer of the skin of the outer bark. Again they stand out conspicuously white against the natural color of the plant they infest, naked, glossy and smooth.

The male scale is pure white, exuvia pale straw color. Length 1 to 1.5 mm. or .04 to .06 inches. The male scales cluster together in dense chaffy patches, preferably on the lower parts of the branches of young trees, and on the trunk near the ground giving the impression of a coat of whitewash at a distance from the tree. A scattering male scale can generally be found here and there among the females. The adult male is a minute, two-winged insect, bright red in color, with darker head and pale legs. The treatment of orchards and remedies advised in the control of the San Jose scale will be equally effective in the control of this species.—(Bul. 61 Fla. Exp. Sta.; 1905 Year Book, U. S. Dept. Agr.)

The San Jose Scale.—Under normal conditions the San Jose scale can kill a young orchard in three years if the infestation is brought in with the nursery stock. If it gets in later, the older trees resist better and less injury is caused. Very old and rough-barked trees sometimes resist perfectly and at the present time, the scale has lost some of the virulence of its early days. In no case, however, should the presence of this scale be lightly esteemed in a peach orchard, for even a single favorable season of unrestricted breeding may irretrievably injure its trees. (For a complete description and remedial measures see page 32.)

*The Terrapin Scale.**—The Terrapin Scale is one of the soft or naked scales, the outer covering being a hardened portion of the derm and not a wax secretion combined with cast skins, as is the case

* See page 645, for illustration.

with the San Jose Scale. This scale insect can be most easily identified during its hibernating winter stage. The scale is hemispherical in form and at this time is about 2 mm. in length and slightly less in width, mottled brown, with radiating streaks of black toward the sides, and an orange red patch on the top, the sides being more or less ridged. Sometimes individuals will be observed to be entirely red or black. As the females develop in spring, the size increases and at full growth the scale is about 3 mm. in length and of nearly uniform reddish brown color. The eggs hatch about June 1 and the larvæ immediately crawl to the leaves, usually on the under side. They remain here for a period of two months, then return to the twigs to winter.

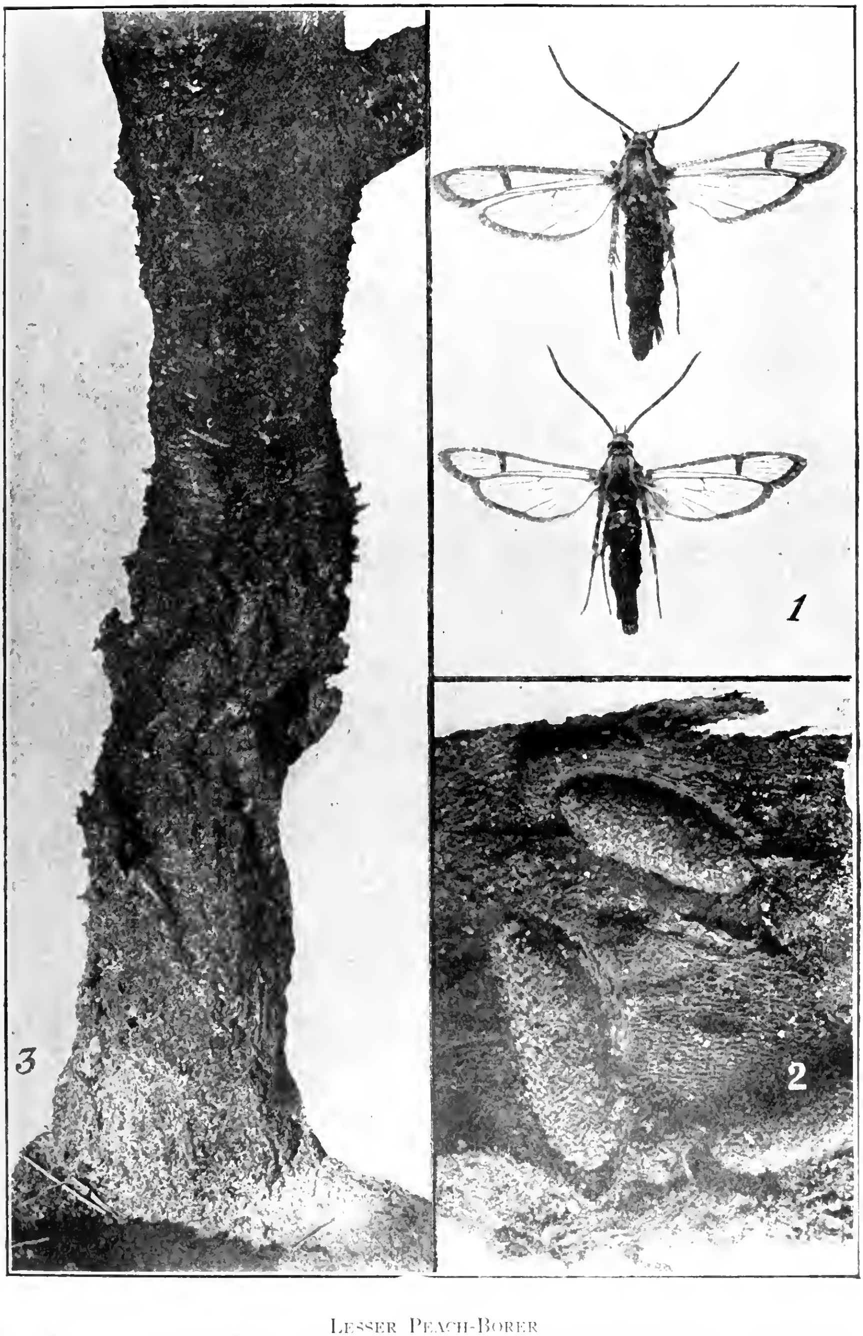
From the above results we recommend that a standard miscible oil be employed at a strength of 1 to 15, applied on the trees just as late in the spring as possible before the buds open. In cases of slight infestation, where only a few trees are affected, it is best to seek out all such trees and treat them with an oil at the rate of 1 to 15. Inasmuch as such an inspection may not discover all cases of infestation, it would seem advantageous to spray the balance of the trees with the same mixture diluted at 1 to 20. This dilution will reduce the possibility of the spread of the scale as well as the likelihood of any injury to buds or twigs from oil.—(Bul. 235, N. J. Exp. Sta.: Bul. 149, Md. Exp. Sta.; Cir. 88, B. of E. U. S. Dept. of Agr.)

*The Peach-Tree Borer.**—In the form in which it is most familiar to the grower, the peach-tree borer is a white, grub-like caterpillar with a yellowish or brownish shield-like head, which lives and feeds in the tree trunks at or just below the surface of the ground and makes irregular galleries or chambers just beneath the bark, from which gum and sap ooze out to form conspicuous masses. These borers may be found at almost all periods during the summer, but are usually very small in late summer or fall and become an inch to an inch and a half in length in early summer.

The parents of this borer belong to the Sesiid or clear-wing moths. The male is a shining, slender, steel blue, wasp-like creature with two pairs of transparent wings marked with black and yellow scales, and the abdomen is narrowly banded with yellow. It expands about an inch when the wings are fully spread. The female is decidedly larger and stouter, deep blue except for a broad orange band around the middle of the abdomen, the hind wings only transparent. The larvæ feed all summer and during the winter lie dormant doing no feeding but begin to do so with the rise of sap.

Trees of all ages may be and are infested by borers, from the seedlings in the nursery to the venerable old relics still to be found in some gardens. In nursery trees and in small trees generally, a single larva may completely girdle and kill a tree. The work is usually done just below the surface of the ground. There is no insecticide application thus far known that can be relied upon to kill borers once in the trees.

* See page 285.



LESSER PEACH-BORER

1. MALE AND FEMALE MOTHS. 2. COCOONS UNDER BARK. 3. TRUNK OF A TEN YEAR OLD PEACH TREE INFESTED WITH LARVAE. (FIGURES 1 AND 2 MUCH ENLARGED; 3, MUCH REDUCED.) DEPT. OF AGR.

An existing or already infested orchard should be carefully examined at least twice in each year: as late as convenient in the fall, and again in the following end of May or early June. In the fall examination the earth should be removed from around the base of the trees to a depth of at least six and preferably eight inches, and every sign of a wound or place from which gum exudes should be investigated. There is needed a small, stiff, coarse brush to remove the gum and crush all surface feeding larvæ; a stout sharp knife to cut through the bark into cavities, and a more slender, longer blade to probe channels and burrows. Never cut more than necessary and never cut across the grain if it can be avoided. If a larva can be located, a straight slit through the bark into the cavity so as to hit the borer is all that is needed, and such a wound will heal almost at once. Between the end of May and the middle of June the process above described should be repeated.

Leave the base of the trees exposed for a few days now, to toughen the outer bark and then, before again drawing up the soil, spray very thoroughly with a lime-sulphur, arsenate of lead mixture, to which an excess of lime has been added. Use one pound paste arsenate of lead to every five gallons of lime-sulphur, or one pound of dry arsenate to every ten gallons of lime-sulphur and apply with all the force possible to the exposed crown and for a distance of eighteen to twenty-four inches above the surface. Then cover and hill up at least six inches around the trunk after the application is thoroughly dry. The strength of the lime-sulphur wash may be that of the ordinary winter spray with double the required amount of lime. The object of this application is to hit young larvæ that might later try to get into the trees.—(Bul. 235 N. J. Exp. Sta.; Bul. 73, Georgia E. S.)

The Lesser Peach Borer.—In the course of investigations of the peach borer by the Bureau of Entomology during 1905 another borer was found infesting the peach, inhabiting principally the trunk, especially of old trees or those showing injury from freezing or other causes. This insect, to be known as the lesser peach borer, has been found in western New York and adjacent portions of Canada, in Maryland and Virginia, and in Georgia, so that it would appear to be widely distributed. In the last-mentioned State it is very abundant and is the cause of important injury, infesting principally the trunks of the older trees, feeding on the soft bark, excavating burrows after the manner of the true peach borer. It has, however, been frequently taken at the crown of the root, and under these circumstances might readily be confused with the other species. This borer is the larva of a moth, both sexes of which are very similar to the male Peach-Tree Borer Moth. To control this species it will be advisable to closely examine the trunks as well as the crowns of the roots during the time of worming for the peach borer.

The Peach Twig-Borer.—One of the most common enemies of the peach in the United States, is the twig-borer, or "bud worm" as it is sometimes called. Its occurrence has been reported from most of the peach growing states of the Union, both in the East and

West. The twig-borer is principally an enemy of the peach, and usually we hear of it in connection with its damage to this fruit. It may be found, however, on all stone-fruit trees, but shows a decided preference for the peach. The larvæ, hibernate in the little silk-lined chambers constructed within the bark and very close to its surface.

In the spring of the year, about the time the peach trees bloom, the larvæ leave their winter quarters and eat into the tips of the twigs, either beginning their work at the extremities or a short distance below, sometimes hollowing them out for usually a distance of less than an inch from where the twig was entered, leaving a mere shell or hollow cylinder of the portion in which they have fed. Again they may merely gouge out the tip of a twig on one side, entering in as far as the pith and then leaving for some other twig. Thus they go from twig to twig, feeding first in one and then in another, until often the tips of a great many branches will be killed back, thereby checking their growth and more or less injuring the tree. The detection of their work is no difficult matter a short time after they begin feeding, for the leaves of affected twigs soon wilt, and later dry up from the injury done to them.—(Year Book 1905, U. S. Dept. of Agr.; Bul. 169, Col. Exp. Sta.)

The twig-borer moth is a tiny, gray insect, about ¼ inch in length and having a wing expanse of about ½ inch. It is quite a beautiful little moth with its dark gray, fringed wings. It may be said that arsenate of lead, applied in the spring at the time the buds of the peach are beginning to open, will control the peach twig-borer as effectively and cheaply as the lime and sulphur wash, up to 50 gals. of water when the buds show pink at tips.—(Year Book this time the most universally used. Use at the rate of 5 lbs. to 1905; Col. E. S. B. 169.)

The Brown Mite.—This mite passes the winter almost entirely in the egg stage. These eggs are tiny, red spherical-shaped, glassy objects, usually deposited in or near crotches of the branches. Hatching takes place in the spring. At first the young mites are red in color and have only six eggs. Upon feeding for a short time moulting takes place, after which the mite is olive green, or brown in color, and has eight legs more or less tinged with red. It feeds principally upon the leaves, occasionally attacking the fruit, and may be detected by the faded out, pallid appearance of the foliage, dotted here and there with little black specks of excreta. Apple, peach, plum, cherry, pear, and almond trees were found infested. Apricot and quince do not seem to be troubled. Flowers of sulphur, one pound to three gallons of water, and enough soap so that the sulphur will mix with water, is a perfectly effective remedy when used as a summer spray.

The Red Spider.—This mite differs from the preceding one in its wintering habits; instead of living over in the egg stage, as the brown mite does, this species hibernates in the soil as an adult, close to trees upon which it has been feeding, or underneath rubbish of any kind. Eggs are laid in the spring by mites that have lived through the winter. These eggs are pearly white, and may be seen as tiny specks on the under surface of the leaves.

When first hatched from the egg this mite, like the species previously treated, has only six legs, the fourth pair developing with the first moult. They are somewhat smaller than the brown mite, usually green in color while feeding upon the foliage of trees, with minute black dots on the dorsum of the abdomen. When feeding ceases in the fall, and they begin their downward migrations to the soil, they become an orange, or red color. Unlike the brown mite, the red spider has the power of spinning a web, and may easily be detected, when prevalent, by the presence of these webs on the foliage, or branches of infested trees. The appearance of injured peach foliage is not unlike the appearance of that injured by the brown mite, but is more inclined to turn yellow in patches. A sulphur spray, the same as is recommended for the brown mite, is probably better than anything else that could be used during the summer months.—(Bul. 169 Col. Exp. Sta.; Bul. 152 Col. Exp. Sta.)

California Peach-Tree Borer.—The most injurious insect in the Santa Clara Valley is generally conceded to be the California peach-tree borer. This insect is most abundant on peach and apricot trees, or on prune trees growing on peach and plum roots. It bores into the bark just beneath the surface of the ground, and is most easily recognized by the very characteristic masses of gum that exude from the tree at the point of attack. These borers often become so abundant as to entirely girdle large trees, causing their death; and even when not so deadly their attack seriously cripples the tree. The labor necessary to dig out or otherwise destroy these insects amounts to a great deal. This insect is best known in its winter quarters, because it is during the winter that practically all of the work for its repression is done.

With the commencement of the flow of the sap in the spring, the older larvæ proceed to the formation of their transformation tubes. These are sometimes, indeed quite commonly, formed within the burrows, especially if the amount of gum has not been excessive. In other cases they will be upon the surface of the bark at, or near, the mouth of the burrow. The most evident sign that the worm is working in the bark of the tree is the exudation of a greater or less mass of gum from the burrow.

Ordinarily, there seems to be a great deal of variation in the shape and direction of the burrow—about as many burrowing up as down. The general direction of the burrow is usually more nearly vertical than horizontal, though a few may go directly around the tree. The remedy, upon which the most dependence is placed in fighting the Eastern peach-tree borer, is that of digging out the worms.

The time of the digging-out is almost always made a matter of convenience, and the facts we have so far learned in regard to the life history do not, as yet, prove that better results would follow a different practice. An important feature of the digging-out method is that it is extremely difficult to find all, or even the larger worms, in a tree; and if the worms are small their discovery is almost or quite impossible. A single going-over of the trees is thus only partially effective, and many orchardists have found that three times during the winter will not exhaust the supply, even though it is quite certain that no moths were flying during the intervals. The rush of other work usually prevents a summer digging-out of the worms, though it would seem that just as good or better results might follow from work at that season.—(Bul. 143, Cal. Exp. Sta.)

The Peach and Plum Slug.—The adult sawflies are very active little insects. If one is observed on a leaf it will be seen to run back and forth across the leaf on the upper side, apparently peering over the edge, occasionally stopping for a moment at one of the nectaries at the base of the leaf and sipping the nectar. This sort of food seems to constitute their diet, as, in addition to visiting the peach-leaf nectaries, they were also observed visiting near-by cotton plants for nectar and honeydew, and one was seen on Japanese quince.

The first damage by the larva consists in very small pinholes eaten into the leaf from the underside, all of the tissue being removed except the upper epidermis. As the larva grows and its jaws become stronger the size of the eaten patches increases until they become large blotches. The upper epidermis is, however, never eaten. So serious a menace is this insect to the peach and plum trees that, in a favorable season, the trees are completely defoliated in August.

Lack of time prevented the writer from making any tests of remedies. Without doubt, however, an arsenical spray, such as arsenate of lead, would very effectively destroy these insects, and this poison is advised when the insects occur in sufficient numbers to warrant treatment. The rapid increase in the spraying of peaches and plums with arsenate of lead in self-boiled lime-sulphur wash for the control of the plum curculio and fungous diseases of the fruit will unquestionably result in keeping the peach and plum slugs well reduced in orchards. Its occurrence in injurious numbers is to be looked for largely in small unsprayed home orchards, and the remedial measures indicated should be followed when its presence in undue numbers is noted.—(Bul. 97, Part V., B. of E. U. S. Dept. of Agr.) [See "Apple Insects."]

PRUNE AND APRICOT INSECTS.

The European Fruit Lecanium.—The insect heretofore generally known as the brown apricot scale belongs to the subfamily of scale insects, the *Lecaniinæ,* being naked but with hardened derm, and differs from the San Jose scale and European pear scale in that the horny covering of the full grown scale is a part of the body of the insect, while in the case of the other species mentioned the body is protected by a waxy covering made up from secretions and the molted skins of the larvæ. The adult female of the European fruit Lecanium is about one-eighth to three-sixteenths of an inch long, three-thirty-seconds to one-eighth of an inch wide, and about one-eighth of an inch high, yellowish in color, marked with black. The older scales are shiny, oval, convex, and often covered with a mealy pruinose deposit.

Distillate-oil emulsions at 6 per cent strength and crude-oil emulsion at 12 per cent strength, measured by their efficiency against scales and lichens, convenience of preparation and application and cost, are the sprays best adapted for the European fruit Lecanium. All sprays, to insure the best results, should be applied with a power outfit at a high pressure (180 to 200 lbs.). A coarse, drenching spray applied with a crook nozzle is preferable, and February is the best month in which to spray.—(Bul. 80, Part VIII., B. E. U. S. Dept. of Agr.)

INSECTS AFFECTING THE PLUM.

The Plum Curculio.—The small, crescent-shaped punctures so commonly found on plums and other stone fruits in orchards east of the Rocky Mountains are made by a small snout-beetle of rough sculpture, known as the plum curculio. These bettles issue from their winter quarters about the time the trees are in bloom, and feed on the tender foliage, buds, and blossoms. Later they attack the newly set fruit, cutting small circular holes through the skin in feeding, while the females, in the operation of egg laying, make the crescentic cuts so characteristic of this species. The egg, deposited under the skin of the fruit, soon hatches into a very small whitish larva or grub, which makes its way into the flesh of the fruit. Here it feeds greedily and grows rapidly, becoming, in the course of a fortnight, the fat, dirty white worm so well known among fruit growers.

To be reasonably effective in killing the beetles, arsenate of lead should be used at the rate of 2 pounds to 50 gallons of water. Paris green or green arsenoid should not, on stone fruits, be used stronger than 1 pound to 150 or 200 gallons of water.—(Cir. 73, U. S. Dep. of Ag., B. of E.; Bul. 25 Indiana Agr. Exp. Sta.)

The Peach Tree Borer: See pages 54, 55, and 57.

The Plum Slug (The Pear Slug): See pages 47 and 58.

The San Jose Scale: See page 32.

The Plum Gouger.—The gouger is a small snout-beetle, about a quarter of an inch long. Its method of work is much like that of the curculio. It is mottled brown in color, with short whitish hairs that give it a pruinose appearance. It can be easily distinguished from the curculio by its size and by the absence of humps on the wing-covers. It confines its work for the most part to the Mississippi valley and the West.

The adult beetle hibernates in the winter, and in the spring attacks the flowers of the plum in a manner at once peculiar and ingenious. The part eaten is the ovule or the part which would, if uninjured, in time become a fruit. The gouger eats a hole in the side of the calyx, the green cup at the base of the flower, and reaching in with its long beak eats the coveted part. Later the gouger eats holes in the young fruit, sometimes laying eggs therein. The egg is laid in a hole in the fruit with no crescentic flap as in the case of the curculio. The young grub works directly into the soft pit, and lives there, leaving no indication of its presence, except perhaps a scar on the outside of the fruit and the gum which exudes from it. Sometimes, however, a malformation of the fruit results. Here in the pit, the pupal stage is passed, and during the latter part of August, the adult beetle emerges. The fruit usually does not fall until just previous to the exit of the inhabitant.

During the period of bloom and just before and after this period, the beetles may be obtained by jarring, just as is done for the circulio. Jarring should be kept up just as long as the beetles are obtained, for one little beetle obtained early in the season amounts to a good deal. It must be borne in mind that the gouger does not thin the fruit as does the curculio, but that the gouged fruit remains until late, drawing on the strength of the tree about as much as a perfect plum.

As most of the fruit falls before the beetles make their exit, immediate destruction of fallen fruit will make away with many beetles. Hogs accomplish this very nicely but if hogs are objectionable, pick up the fruit by hand and bury it just as soon as it falls. The arsenites do not seem to prove as beneficial as we could wish, but no doubt they will pay for the application. Prof. C. P. Gillett of Colorado, recommends the hand picking of all gouged fruit. This combines the benefits obtained by thinning, with those resulting from the death of the insect.—(Bul. 24, Mich. Agr. Exp. Sta.)

The Plum Leaf-Miner.—The plum leaf-miner in its injurious stage is a smooth, greenish white larva, one-sixth inch or less in length, found during late June and early July feeding between the outer layers of the leaf. Hatching from an egg attached to the under surface of the leaf, the larva penetrates the tissue and first eats a narrow linear mine an inch or less in length, then widens the mine so as to produce an irregular, more or less ovate blotch about one-half inch long. The part of the leaf so injured turns brownish and dies. From three to twelve mines are often found in a single leaf. The trees become partially defoliated and the fruit may fall prematurely. When continued for a series of years this injury tends to weaken the vitality of the tree and to injure the size and quality of the crop.

The adult of the plum leaf-miner is a small bronzy black moth having an expanse of one-seventh to one-fifth inch. The forewings are crossed by a shining white band on the outer third, and the head bears a conspicuous orange tuft. These moths emerge from cocoons at or near the surface of the ground during the daytime in the latter part of May and in early June. During the day they remain quietly on the bark of the trunk and larger branches, none being found on the leaves. Several hundred moths are often found on a single tree; when disturbed they suddenly take flight and most of them settle on the opposite side of the tree. They gradually decrease in numbers, and about the middle of June they disappear.

God furnishes the ideal winter quarters for the cocoon. The plum leaf-miner has proved to be a difficult insect to control, owing to the fact that from the time the larva leaves the egg it feeds entirely within the leaf out of reach of any poison spray. Measures directed against the moths, eggs and larvæ have all proved failures, and only partial success has been attained by thorough cultivation to destroy the larvæ and pupæ in their cocoons. However, thorough cultivation seems to be the only remedy at hand at present.

Plum Aphids.—Several species of plant lice infest the plum, the two most important being the true plum-louse which remains on the plum all the year round; and the hop-louse. This latter species is restricted to regions where hops are grown, as a matter of course, and migrates, back and forth between the two host plants, spending the summer and early fall on hops, and late fall, winter and spring on cultivated or wild plum. In other words the eggs are laid on the plum branches in October to hatch out the following spring. The young lice which are at this stage provided with wings, migrate to the hop yards for the summer, their progency coming back to winter quarters in the fall. The true plum-louse remains the year round on the plum trees, curling the leaves and sometimes doing considerable damage. The ordinary spray of kerosene-emulsion, or tobacco-water, will kill the lice easily enough if they can be reached. Very thorough work in the central part of the tree is required to hit them because of the curled condition of the leaves.—(Bul. 308, Cornell Exp. Sta.; Bul. 24, Mich. Exp. Sta.)

INSECTS AFFECTING THE CHERRY.

The Divaricate Buprestis.—This is a medium sized beetle with very hard, strong wing-covers and a flattened body. The surface is bronzy, and furrowed, the spaces between furrows being highly polished. This insect bores into living wood much as does the flat-headed apple-tree borer. It works in cherry and most of our stone fruits beside a number of forest trees. The remedies are the same as those for the flat-headed borer of the apple.

The Cherry-Tree Plant-Louse.—A large, black, polished plant-louse that works on the young shoots and tender foliage of the cherry, often appearing in very great numbers. They multiply rapidly, sometimes covering the twigs and young fruit, and secreting a sticky sweetish liquid called honey-dew. This attracts ants, yellow-jackets, flies, etc. Late in the season they often become numerous before laying the eggs for the spring brood. Kerosene-emulsion or any of the contact insecticides, applied in the ordinary way, except that it should be a little stronger than when used for green lice. It must be borne in mind that each louse must be hit in order to be killed.

The Cherry Leaf-Beetle.—A small, dark-red beetle less than one-fourth of an inch in length, oval in form, and with the antennæ and parts of the legs black. The small beetle feeds on cherry. The writer has seen them in great numbers on pin cherry (a wild cherry) at AuTrain Falls in late August. The beetles have welcomed with enthusiasm the introduction of the cultivated cherry in their haunts, readily accommodating their taste to the new food. They feed on the leaves, and often come in large numbers, appearing in June and again in September. In the Northern Peninsula they do a great deal of damage to young trees, coming out of the ground from a depth of several inches, and attacking the young foliage about the first of June. The larvæ also works on the foliage, following the adults.

When on old trees not in bloom, these beetles may be killed with paris-green and lime, one pound of the poison to one hundred and seventy-five gallons of water, but on very young trees the case is more difficult. Mr. Geismar, the superintendent of the Upper Peninsula Experiment Station, points out the fact that the beetles either hibernate or pupate under the surface of the soil, often at a depth of several inches, and usually within a few inches of the base of the tree. He finds also that they are almost sure to climb the tree instead of flying, being somewhat sluggish on first coming to the surface. This suggests the use of narrow bands of sticky fly-paper or loose cotton at such times in the case of young trees. The beetles eat very voraciously and a few dozen can work havoc in a young tree, especially if it is in bloom and one does not wish to spray.

[Bud Moth, see page 43; Cherry Slug or Pear Slug, see pages 47 and 58; Apple-Tree Tent-Caterpillar, see page 39; White-Marked Tussock-Moth, see page 41; Canker-Worms, see page 38; Fall Web-Worm, see page 39.]

INSECTS AFFECTING THE BARK.

[Fruit Bark-Beetle, see page 32; San Jose Scale, see page 32.]

The Cherry Fruit-Fly.—The work of this cherry maggot causes large losses. The maggots feed upon the juicy flesh of the ripening cherry, usually near the pit. They form an irregular, rotten-appearing cavity which is represented by the black cavity near the pit. Until the maggots get nearly full-grown their work does not show on the surface of the fruit. Soon after picking-time, however, the rotting extends to the skin which sinks in. Usually but a single maggot is found in a cherry; we have sometimes found a second, but always much smaller, maggot in the same fruit. The maggots do not tunnel all through the flesh of the cherry as does the apple maggot in apples. The insect doubtless spends the winter in the soil, usually not more than an inch below the surface. During the spring months, the transformation from a pupa to the adult insect takes place.

Doubtless the pest will spread quite slowly from tree to tree and thus from orchard to orchard, as the adult insects are slow in their movements and are not long-fliers. This is a very important fact for it makes the checking of this new cherry pest largely an individual matter, to be worked out independently by each cherry-grower. Doubtless the sweetened arsenical sprays now employed against the apple maggot adults will be found effective in this case. The insects of the peach and plum are nearly identical.—(Bul. 172, Cornell Agr. Exp. Sta.)

GRAPE INSECTS.

The Grape Root-Worm.—As the name indicates this worm infests the roots of the grape, devouring more or less completely the smaller roots and rootlets and eating pits or burrows into the outer portion of the larger roots. It is the larva of a small, hairy, chestnut-brown beetle which makes its appearance in vineyards at about the close of the blooming period of such varieties of grapes as Concord, Niagara, Catawba, and Delaware. The beetles feed freely on the upper surface of the leaf, eating a series of patches or holes through to the lower surface, thus producing characteristic chain-like feeding marks, by which their presence in vineyards may be readily detected. The injury to the foliage, however, it quite unimportant compared to the work of the larvæ on the roots. When the larvæ are abundant the vines may be killed in the course of a season or two, but usually the plants will live longer, though making but a feeble growth and failing to produce profitable crops. The death of vines or the gradual failure of a vineyard should call for an examination of the foliage for the feeding marks of the beetles and of the roots for the work of the larvæ on these parts.

The grape root-worm, or grapevine *Fidia,* is without doubt a native species, feeding originally on wild grapes, as it does at the present time. In addition to cultivated varieties of grapes it has also been recorded as feeding on the Virginia creeper and the American red-bud.

The beetle, or parent insect of the grape root-worm is about one-fourth of an inch long, rather stout, with long legs, the body brownish in color and covered with grayish white hairs. The adults make their appearance in vineyards beginning about the close of the blooming period of the vines, which in the New York, Pennsylvania, and Ohio grape districts, during normal seasons, will be from about the 15th to about the 20th of June. The great majority of beetles will appear during the latter part of June and the first two or three weeks of July, though a few will be coming out during the latter part of July, and stragglers may appear for a month or six weeks later. In a given locality there will be some variation in the time of appearance, which will be earlier on light, sandy soils or warmer locations and later on heavier soils. In the course of a few days after emergence the beetles begin to feed, eating rows of holes in the upper surface of the leaf. Eggs are deposited in patches usually from 25 to 40.

On hatching, the larvæ drop to the ground. At this time they are about one-seventeenth of an inch in length, and from their small size are readily able to find their way through the soil. Although the powers of locomotion and endurance of the young larvæ are considerable, to enable them to overcome difficulties in reaching their food, many doubtless fail to do so and perish. When established on the roots, however, the grubs feed freely and grow rapidly. By fall the majority of them will be full-grown or nearly so. Upon the approach of cold weather they descend into the earth several inches, a few as much as a foot below the surface, and here construct oval earthen cells in which they pass the winter. With the approach of warm weather the larvæ ascend to a point near the surface, the immature ones completing their growth, and the pupal stage is entered mostly from about 2 to 3 inches below the surface of the soil and within a radius of 1½ to 2 feet from the base of the vine. The full-grown larva is about five-eighths of an inch long, the body whitish, resting in a curved position. The head is yellowish brown in color, with a transverse diameter somewhat less than that of the body.

The full-grown larva prepares an earthen cell, within which it shortly changes to the pupa or turtle stage. In this condition the insect is soft and helpless, and the earthen cells are readily broken open and the pupæ crushed or otherwise killed by stirring the soil. As stated, the majority of the larvæ pupate about 2 or 3 inches below the surface of the ground, and this makes possible their destruction in large numbers by timely cultivations, as will be explained under the discussion of remedies.

The insect may be fought in three important ways, namely, by poisoning the adults with an arsenical spray, jarring them from the vines onto sheets, and destroying the pupæ in the soil by cultivation.

Shortly after emergence the beetles begin to feed upon the foliage, eating holes in the upper surface of the grape leaves, and hence may be readily poisoned. To be effective, however, the poisoned spray must be applied at the right times and with great thoroughness. The beetles begin to put in an appearance at about the close of the blooming period. Careful watch should be kept, and upon the first signs of the chain-like feeding marks on the leaves the vines should be thoroughly sprayed with a poison. A second application should be made in a week or ten days. These applications are intended to poison the newly emerged beetles during their first feeding and before they have deposited their eggs to any extent. If applications be delayed two or three weeks beyond the time indicated, a considerable percentage of the eggs will have been deposited, and the treatments will lose much of their value. Vineyardists having this pest to contend with should not make the mistake of spraying a little too late, but should have everything in readiness to begin applications upon the first appearance of the beetles. The beetles plainly avoid feeding on foliage sprayed with Bordeaux mixture or arsenate of lead, seeking the unsprayed leaves as much as possible. It is therefore especially necessary to make applications with great thoroughness, poisoning as nearly as possible the upper surface of every leaf, so that the beetles will be poisoned or forced to leave the vines for food. This desired thoroughness of treatment is not obtained as a rule by vineyardists, and greater care should be exercised in this work. In commercial vineyards the tendency will be to hurry through the work, covering 12 or 15 acres per day, using an insufficient amount of spray. With the spraying machinery in common use 7 to 8 acres per day is about all that may be covered with the desired thoroughness and about 125 gallons of spray mixture should be applied per acre. In spraying for the grape root-worm, the poison, 3 lbs. of arsenate of lead should always be applied in Bordeaux mixture.

Doctor Felt has made extensive practical tests of jarring the beetles from the vines and catching them on sheets or special forms of catchers run under the plants or along the rows, and considers this to be an effective plan of controlling the pest, the jarring of the vines causing many of the beetles to fall in their efforts to escape detection. A sheet of canvas placed on the ground beneath the vines will serve to catch the beetles, but where work of this kind is done on a large scale special apparatus must be provided. There is room for considerable ingenuity in constructing catchers that will suit individual conditions. Concerning the value of jarring, Doctor Felt said—Our experience with collectors has demonstrated the practicability of catching the beetles, and we recommend this operation for all badly infested sections, and that the collecting be begun as soon as the beetles appear on the vines in any numbers, say where there are 12 or 15 on one. The operation should then be repeated at intervals of 5 to 7 days till the vines have been gone over two, three or four times, depending somewhat on the number of insects which are captured. It will be found that it is much easier to catch the beetles on warm days, when it should be done, than in cool weather.

While the grape root-worm may be present in well cultivated vineyards, it is much less destructive than in vineyards which receive indifferent cultivation or total neglect. It has long been known that much good may be done in controlling insects which live underground by breaking open their pupal cells and crushing or otherwise killing the helpless pupæ. After the larvæ have become full grown the great majority pupate but 2 or 3 inches below the surface of the soil, and mostly within a radius of 1½ or 2 feet from the base of the vine. In this stage the insects are quite helpless, and are killed in large numbers by a thorough breaking up of the soil around the base of the plants. The details of this work are very important and require explanation.

With the last cultivation in the fall the earth should be thrown to the vines on each side, forming a ridge along the row. The following spring the larvæ in making their way toward the surface of the soil to pupate will mostly work up in this ridge of earth, above the surface of the roots, and there enter the pupal stage. The cultivation of the vineyard in the spring should be so adjusted that this ridge of earth may be thrown away from the vines when most of the insects are in the pupal stage, as one of the regular cultivations. An implement known as a "horse-hoe," generally used in vineyards, may be employed to great advantage in this work; but as it is not practicable to remove the earth from immediately around the vine owing to danger of injury, it is necessary to follow the horse-hoe at once and remove the earth with a hand-hoe. The latter work is also done as a part of the regular vineyard treatment to keep down weeds and grass and is timed so as to supplement the plowing with the horse-hoe for the insect. Following the removal of the ridge of earth from along the vines, it is well to keep the ground stirred at frequent intervals by means of a cultivator to further insure the destruction of the pupæ.

Grape Berry Moth.—The larva of the grape berry moth infests the berry or fruit of the grape. The first generation attacks and webs together the grape clusters even before the blossoms open or soon after the grapes are set. Later-appearing larvæ bore into the green or ripening fruit and produce a purplish spot much resembling in appearance the injury due to the black-rot fungus, with which it is frequently confused. Within the fruit the larvæ feed on the pulp and seeds, passing from one grape to another, and several of these discolored and shriveling berries will often be found more or less webbed together with numerous particles of larval excrement, and sticky with exuding grape juice. The American grape berry moth occurs from Canada south to the Gulf and westward to California. In some vineyards a loss of from 25 to 50 per cent of the crop is not infrequent, and in occasional instances the destruction of the fruit is practically complete.

The grape berry moth is small, the wings expanding not quite one-half inch. The general color is purplish brown, the wings with markings. Moths appear in the spring from hibernating pupæ, beginning about the time the shoots of the grape are pushing out, and continuing to emerge for some weeks. The earlier-appearing individuals deposit their eggs on the blossom clusters, while those coming out after the blossoms are shed oviposit on the clusters of young grapes.

About 3 weeks are required for a larva to complete its growth in summer, when it is about three-eighths of an inch in length, slender, light greenish to purplish in color, the head slightly bi-lobed, greenish above, and brownish in front, the thoracic feet blackish. When ready to pupate the larvæ go to the leaves, and a small portion is cut loose, except along one side, and bent over and fastened down with silk. Beneath this a thin, whitish, silken cocoon is spun, and in 3 to 4 days the larva changes to a light greenish brown pupa, from which the moth will emerge in some 12 to 14 days. Second-brood larvæ infest the grape during July and August, the later-appearing individuals probably not developing to moths but hibernating in the pupal condition. Many of the earlier-appearing insects of this brood appear to complete their life cycle, and moths develop, giving rise to a third generation of larvæ.

The use of arsenical poisons against the first brood of the grape berry moth was recommended by Mr. Marlatt, of the Bureau of Entomology, in 1895. Since this time the recommendation has been amply justified in the experience of numerous vineyardists, who, in connection with the fight against the grape root-worm, found that their early sprayings for this pest were also controlling the grape berry moth. Professor Slingerland reports an instance in which three timely applications of arsenate of lead, at the rate of 10 or 12 pounds to 100 gallons of water, gave almost absolute protection during the rest of the season.

As would appear from the life history of the insect, most effective work may be done by destroying the first brood larvæ, which feed in the clusters of blossoms and berries. The first treatment should be made just before the blossoms are ready to open, and the second just after the blossoms have fallen. A third treatment in a week or ten days is also advisable in badly infested vineyards. In all these treatments special care should be exercised to force the spray well through the clusters of blossoms and young fruit. It will be noted that the second and third treatments for the grape berry moth will coincide with the first and second treatments for the grape rootworm, and the arsenicals recommended for that insect will be equally satisfactory for the grape berry moth.

This practice is often followed by vineyardists, and is especially directed against larvæ of the second brood. The infested spotted green berries, which are readily seen, should be carefully searched for and destroyed. This practice will lessen injury from a possible later brood, and if carefully followed would reduce the insects materially in the vineyard from year to year.

Inclosing each cluster of grapes in a paper bag soon after the blossoms have fallen should protect them from injury from second and third-brood larvæ, and would also afford protection from the rose-chafer and from black-rot. This practice is especially useful in the small home vineyard.

The fact that the insect passes the winter in fallen leaves has led to the recommendation that these be raked up and burned. From Mr. Johnson's observations it would appear important to collect these early in the fall, as the pupæ are to be found mostly on the 10 or 15 per cent of leaves which fall first, and great care must be taken to collect those leaves more or less imbedded in the soil. After remaining on the ground for a while, probably many of the cocoons break off from the leaves and would thus not be collected with the leaves. It is probable also that many of the insects could be destroyed by covering the leaves with soil early in the fall.

Grape Curculio.—The grape curculio is one of the snout beetles belonging in the same family as the so-called plum curculio. The parent beetle deposits her eggs in little cavities which she eats into the grapes, and the resulting larvæ feed upon the pulp and seeds, producing an injury quite similar to that done by the grape berry moth. The beetles cut small, rather characteristic holes in the grape leaves when feeding, and the berries often show a purplish coloration at the point punctured in egg-laying. If infested berries be examined it will be readily possible to distinguish between the grape curculio and the grape berry moth, since the grubs of the former are whitish and quite destitute of legs, whereas the larvæ of the berry moth have well-developed legs, are greenish in color, quite agile, and likely to escape quickly upon being disturbed.

The grape curculio is a native species, feeding originally on the wild grape, as it does at the present time. Mr. Brooks has shown that the insect is readily controlled with arsenical poisons and, as will be detailed later, treatments for the root-worm and berry moth will also keep this pest under control.

The insect passes the winter in the adult or beetle stage, hiding under trash in and near vineyards, especially bordering woods. About the time in the spring that the grape is in bloom the beetles come from their hibernation quarters and for the first few days or a week are quite sluggish, but gradually become more active, feeding on the foliage of the grape until the berries are about one-fourth grown or of sufficient size to be suitable for receiving the eggs—according to Mr. Brooks, in 1905, covering a period of about 25 days. This habit of feeding on the exposed portions of the vines some 3 to 4 weeks before egg-laying permits of their ready destruction by arsenical poisons. Late in June, in the latitude of West Virginia, the females begin depositing eggs in the berries, excavating a cavity in which a single egg is placed. About 4 to 6 days, varying with the temperature, are required for the eggs to hatch, and the resulting larva burrows through the pulp, reaching the seed in 3 or 4 days, which is penetrated and the contents devoured. In 12 to 15 days the larva has become full grown and leaves the berry by eating a hole to the outside, falls to the ground and at once seeks a suitable place for pupation, as under stones, lumps of earth, or just below the surface of the soil. Here an earthen cell is made and the larva transforms to the pupa, the adult beetle emerging in the course of 18 or 19 days, at first blackish in color with gray hairs, but soon becoming the normal brown color.

The beetles feed freely upon the foliage of the grape in the spring for several weeks before egg-laying begins and continue feeding in the fall after egg-laying ceases along with beetles of the new generation, and it is thus an easy matter to bring about their destruction by arsenical sprays. The treatments advised for the grape berry moth and root-worm, with perhaps an additional treatment 2 or 3 weeks later, will practically control the insect.

Fruit may also be well protected by bagging the clusters soon after the grapes have set, as already mentioned in connection with the grape berry moth.

Grape Leaf-Hopper.—Throughout the United States and Canada, wherever the grape is grown, this small leaf-hopper will almost invariably be found in greater or less numbers infesting the lower surface of the leaf, where it feeds and breeds, increasing in numbers as the season progresses, until by late summer and fall the vines are often literally swarming with it. Throughout its extended range the insect may be quite destructive in some localities nearly every year, and is likely to become so elsewhere at any time. The grape leaf-hopper is an insidious pest, often not noticed by the vineyardist until late summer and fall, when the yellow and brown-blotched leaves, falling prematurely, attract attention, by which time the injury has been done. The insects in feeding extract large quantities of liquid food, sucking it out from the interior of the leaf by means of their tube-like mouth-parts. When they are abundant this constitutes a heavy drain on the vitality of the plant. The injury to and loss of

Three-Year-Old Peach Tree Injured by San Jose Scale.
Dept. of Agr.
(See page 32.)

Apple Tree Badly Infested with San Jose Scale. Many Branches Killed.
Dept. of Agr.
(See page [illegible].)

leaves prevents the proper assimilation of food by the vines; the fruit may be materially reduced in quantity and will lack much in flavor and sugar content. Although the yearly loss to grape growers from the attack of this species is sufficient to place it among the first-class pests of the vine, but little effort ordinarily is made to control it, perhaps principally because no very practicable remedy has until recently been proposed.

The adult grape leaf-hopper is quite small, measuring not more than one-eighth of an inch in length. It is very agile, moving with almost equal facility in all directions, and flies out from the vines often in swarms upon slight disturbance. The insect passes the winter in the adult condition in hibernation in trash in and near vineyards, in the edges of neighboring woods, in grass along gullies, in ditches, etc. Early in the spring the insects come from winter quarters and attack almost any succulent vegetation at hand. By the time the foliage of the grape appears they are out in large numbers and begin to infest the vineyards. These adult hoppers of the hibernating generation feed and breed on the lower or earlier-appearing leaves, gradually disappearing as the season progresses, but not before some of their progeny have reached the adult condition. Some weeks are spent by the adults in the spring in feeding before egg-laying begins. Eggs are placed just beneath the epidermis in the lower leaf surface, usually singly but also in groups of from 6 to 9, the egg stage, according to Professor Slingerland, lasting from 9 to 14 days. Egg-laying probably continues for two months or more. When just hatched the young hopper is very small, whitish in color, with red eyes, later becoming striped with yellow. In the course of their growth these nymphs molt four times the white skins being very numerous on the lower surfaces of badly infested leaves. The nymphs feed in the same manner as the parents, sucking juices from the leaves, at first on the lower surface of the older leaves where they were born, but later spreading more or less generally over the plant. They are very agile, running in all directions, but do not leap or hop.

The grape leaf-hopper has proved to be a difficult pest to combat successfully. Various practices have been proposed, such as the use of trap lanterns to burn at night, the raking and burning during winter of fallen leaves and trash in vineyards, the use of sticky shields or fans to catch the adults as they fly from the vine on being disturbed, and in California the use of insect nets for the same purpose. Extensive field experiments were made by Professor Slingerland. He found that large numbers of the hibernated adults could be caught on sticky shields carried along each side of the row, the insects being frightened out by disturbing the vines. This work is done early in the season, before oviposition takes place to any extent. A light wooden frame is made, 7 or 8 feet long by 4 feet high. To the crosspiece at the bottom, which should be up from the ground about a foot, are fastened several stiff wires of the shape of a hayrake tooth. These are fastened so that the points curve inward and downward to the ground at base of plants when the shield is held in place beside the vines. The whole framework, including the wires, is covered with oilcloth which is coated with a sticky substance, made by using melted resin, 1 quart, and castor oil, 1 pint.

Early in the season the insects will be found mostly on the lower leaves and the frame need not be high. As the higher leaves are invaded the height of the frame must be increased. In controlling the insects in this way it is very important to catch the over-wintering adults before egg laying has begun, thus greatly reducing the number of progeny to appear later, and the operation of catching the insects must be repeated at frequent intervals.

Extensive tests with sprays were also made, and it was found practicable to destroy the young wingless hoppers or nymphs with a whale-oil soap solution, the soap being used at the rate of 1 pound to 10 gallons of water. The spraying must be done very thoroughly, covering the under surface of the leaves, as only those nymphs are killed which are actually hit with the spray. This work should be begun when it is observed that the young are becoming common. It is likely that an 8 to 10 per cent kerosene emulsion could be used, which would obviate this difficulty, and would prove equally effective in killing the young hoppers.

Thorough cleaning up of fallen leaves and trash in vineyards during the winter will undoubtedly destroy many hibernating adults, and if this work be extended to adjacent areas where the insects are likely to find shelter, the reduction in their numbers will be materially greater. Where practicable the burning over of adjacent meadows, wood lots, and spaces along fences is very advisable. It has been observed that in vineyards in which clean culture is practiced, all grass and weeds being kept down throughout the season, the hoppers are notably less abundant than where this practice is not followed. The absence of suitable hibernation quarters in the vineyard causes them, largely, to migrate elsewhere, and vineyards receiving such care are much less seriously infested the following spring and summer.

The grape leaf-hopper secures its food by sucking juices from the interior of the leaf, and arsenical poisons useful against the grape root-worm and the grape berry moth are quite useless against this pest.

Grape Leaf-Folder.—Observing grape growers have often noticed, especially during midsummer and later, grape leaves folded together, the interior (upper) surface of the leaf being more or less skeletonized, and within the fold a slender larva, which, upon being disturbed, is apt to wriggle out and fall or hang suspended by a thread. This insect, the grape leaf-folder, is widely distributed and a few are to be found in vineyards almost every year, while here and there throughout their range they may be so abundant as to do serious injury. There are two broods each year in the more northern States and three or possibly more in the South. The insect winters in the pupal stage in the folded and fallen leaves, the moths appearing in the spring shortly after the foliage puts out, and the eggs are placed in small patches here and there on the vine. Upon hatching, the young larvæ attack the foliage, folding the leaves as stated. Mr.

Johnson has observed that larvæ of the first brood may attack bunches of grape blossoms and young fruit in a way similar to the grape berry moth. In 3 or 4 weeks the larvæ are full grown and transform to pupa within the folded leaves, moths emerging some 8 or 10 days later. By midsummer and fall the insects may become quite abundant, and in badly infested vineyards the folded leaves are everywhere in evidence and are quite conspicuous from the color of the lower surface. In the fall the larvæ pupate in the folded leaves and pass the winter in these on the ground.

Where the insects are but moderately abundant it will be quite practicable to search out the folded leaves and crush between the hands the larvæ or pupæ within. The destruction of the first brood in this way would greatly reduce the number of the insects later in the season.

Vines sprayed with arsenicals for the root-worm and the berry moth will be well protected from the leaf-folder, for in this way the majority of the leaves will be sufficiently poisoned to insure the destruction of the larvæ and prevent the folding of the leaves. After a leaf has been folded the larva is practically safe from poisoning. As the winter is spent in the pupal stage in the leaves on the ground many of the insects may be destroyed by collecting and burning the fallen leaves, as recommended in the case of the grape berry moth and the leaf-hopper.

Grapevine Flea-Beetle.—Early in spring, as the buds of the grape begin to swell and burst, these may be scooped out or entirely consumed by a small blue or greenish beetle, measuring about one-fifth of an inch in length, of robust shape, with thick thighs, and jumping readily from the vines upon being disturbed. When the beetles are abundant all of the buds on the vines may be quite destroyed, greatly retarding leafing out or even causing the death of the plant. Later the young foliage is eaten by the beetles, the females depositing their eggs more or less on the leaves, but largely, according to Slingerland, in cracks in the bark at the base of buds, between bud scales, or even in the holes which have been eaten into the buds. The resulting larvæ feed on the leaves of the grape, mostly on the upper surface, and are thus readily destroyed with sprays. In 3 or 4 weeks the grubs have attained full growth; then, dropping to the ground, they make an earthen cell an inch or so below the surface, and transform to pupæ, from which the adult beetles will emerge in the course of 1 or 2 weeks. The new brood of beetles feed upon the grape and other plants, going into hibernation in the fall and appearing the next spring to attack the buds of the grape, as stated. In the Northern States Slingerland's studies have shown but one generation of the insect each year. In the South two or more generations annually are supposed to occur, but definite evidence on this point is wanting.

The flea-beetle is native to North America, and occurs very generally throughout the eastern half of the United States, its western limits being Minnesota, eastern Nebraska, Kansas, and Texas. Its natural food is undoubtedly the wild grape, though numerous other plants are fed upon, as plum, apple, pear, quince, blue or water beech, elm, etc.

In vineyards which are regularly sprayed with arsenicals and Bordeaux mixture the flea-beetle will be effectively kept in check. The first application for the berry moth before the blossoms open, together with the application made after the blossoms fall, will destroy the larvæ, since these feed almost exclusively on the upper surface of the leaves. The insects thrive best in neglected vineyards, and may become quite abundant and destructive locally. Where it is desired to treat for this insect only, the vines should be thoroughly sprayed with an arsenical just as the buds are beginning to swell, or somewhat earlier. A close lookout must be kept for the first signs of the beetles, and the poison must be applied immediately. The delay of a day or so may mean the loss of the buds, and hence of the fruit crop. In the small home vineyard it will be practicable to search out the beetles and remove them by hand, doing the work in the morning when they are less agile. As stated, the destruction of the larvæ when feeding on the foliage later will be very easily accomplished by spraying with arsenicals.

It will also be quite practicable, as stated by Doctor Howard, to jar the beetles from the vines on canvas frames placed beneath, which should be kept saturated with kerosene.

Rose-Chafer.—About the time of blossoming of the grape in the spring the rose-chafer may suddenly put in an appearance, often in enormous numbers, the long, spiny-legged, awkward, brownish beetles literally covering the plants, feeding at first upon the blossoms, but later attacking the young fruit and foliage, the leaves being eaten bare, except the larger veins. This insect is a very general feeder; it attacks practically all fruits—e. g., apples, plums, cherries, peaches, etc.—as well as various vegetables, grains, and grasses. Many ornamental plants, such as Spiræa, Deutzia, and roses, are attacked, and its injuries to the last-mentioned have led to the use of the common name of rose-chafer or rose-bug, though it is perhaps now most commonly complained of from its injuries to grapes and other fruits. When abundant, the beetles may do serious injury in vineyards, quite destroying the blossom clusters or the newly set fruit. Berries not actually devoured are often so marked by the beetles that they become misshapen and crack as they grow, the seeds often protruding. After 3 or 4 weeks of feeding the beetles may disappear almost as suddenly as they came.

The insect lives in the larval stage underground, feeding on the roots of various plants, especially on the roots of grasses. In general, it breeds principally in light sandy soils, especially in meadow lands, but also in other places where there is more or less of growth of grass and weeds, and, to a less extent, in cultivated ground. Wet, clayey, or compact soils do not furnish desired conditions for the insects, and from the fact that they are largely confined to the lighter soils it becomes practicable to reduce them greatly by planting these to annual crops which receive thorough cultivation.

The beetles deposit their eggs singly, burrowing beneath the soil, laying, according to Doctor Smith, from 12 to 20 eggs. The resulting larvæ feed upon the roots of various grasses and possibly weeds and other vegetation. They are mostly full grown by fall, and burrow below the frost line, where the winter is spent. With the coming of spring the grubs ascend toward the surface and enter the pupa stage, from which in from 10 to 30 days, varying with the temperature, the beetles develop and attack the grape and other plants, as stated. There is thus but one generation each year, the principal injury of the insect being done during the 3 or 4 weeks of its life as a beetle.

The rose-chafer is an exceedingly difficult insect to combat successfully. When the insect occurs only in moderate numbers, arsenicals will be reasonably satisfactory; but when it occurs in swarms, the plants are reinfested as fast as the insects are killed. A heavy application of arsenate of lead, say 5 to 6 pounds to 50 gallons of water or Bordeaux mixture, with 1½ pints of molasses added, will largely protect the vines. Very thorough applications should be made upon first signs of the insects and repeated as necessary.

The numbers of this insect may be considerably lessened by restricting its breeding grounds. In vineyards on sandy or light soil especial care should be taken to keep the rows and surroundings free from weeds and grass, upon the roots of which the larvæ feed. Sandy meadow lands in the vicinity of vineyards should be broken up and cultivated to annual crops, and in this work the co-operation of vineyardists throughout a neighborhood is especially important.

Bagging grapes as soon as the fruit has set is often practiced, and affords protection not only against further injury from the rose-chafer, but also from the grape berry moth, the grape curculio, and fungous diseases of the fruit.—(Farmers' Bul. 284, U. S. D. of A.)

The Grapevine Root-Borer.—This insect has been recognized as an enemy of the grape in the United States for more than fifty years. It is capable of doing serious damage to grapevines and the slight attention which it has received in the past is no doubt due in a measure to the obscure appearance and habits of the insect throughout the four stages that compose its life-cycle. So inconspicuous is the insect itself, and its manner of working, that a vineyard may be suffering greatly from its attacks and yet those who have the care of the vines remain entirely ignorant of the cause of the trouble. The eggs are small, of a dull color, and the female in ovipositing scatters them promiscuously about in the vicinity of the vines. The larvæ, or borers, feed beneath the ground on the roots of old vines, usually some distance out from the base of the roots. No chips or castings are thrown to the surface to direct attention to the injury which is being done. The roots of one-year-old and two-year-old vines are rarely attacked, so that in the work of planting out vineyards the borer is not likely to be seen. The transformation from larva to adult takes place within an earth-covered cocoon that is hidden in the ground, often six inches or more from the root where the borer fed. The adult moth flies by day, but in size, color and manner of flight it so closely resembles some of the common wasps of the genus *Polistes* that a close scrutiny is necessary in order to make sure that the insect under observation is a moth and not a wasp. As a result of these peculiarities the insect may be abundant in a locality and yet remain unnoticed by grape growers.

Vines when attacked by the borers do not often die as a direct result of the injury sustained, but may become so enfeebled that the annual growth of bearing wood is meager and the yield of fruit very small.

It is in the larvæ stage alone that the insect is capable of doing any injury. When first hatched the larvæ are very small, being only about one twenty-fifth of an inch in length. They are whitish in color with brown heads, and are sparsely covered with stiff hairs. When full grown some specimens attain a length of one and three-fourths inches. As soon as the young borer is out of the egg, which, as stated, is on the ground at the time of hatching, it begins to work its way downward through the soil, evidently trusting good fortune to guide it to a grape root. That the borers can survive at this early age for several days with but little food was shown by placing half a dozen in a small bottle, where they lived for three days and then escaped by tunneling through the cork stopper. During the three days' confinement they had no nourishment except what they might have extracted from the dry cork, which was most likely very little.

The borer, after finding the root, first eats its way through the outer bark and then begins to excavate an irregular burrow, which at first is confined to the softer portions of the bark. At the beginning, this burrow may encircle the root several times, but later, as the borer increases in size, it is made to run with the grain of the wood and may be extended either toward or from the base of the root. The diameter of the burrow is increased with the growth of the borer.

The females, when they are engaged in egg-laying, can very readily be approached and killed by striking them down with a paddle-like instrument or board. If a watch is kept about infested vines from the middle of July to the middle of August the females may be seen and killed in this way.

It is by the thorough cultivation of vineyards that the greatest good is likely to be accomplished in the way of reducing the ravages of this insect. Observation has shown that from the middle of June to the last of July the insects are transforming from the borer stage to the adult stage within cocoons which are located just beneath the surface of the ground in near proximity to grapevines. If, during this period the ground about the vines is thoroughly cultivated, most of these cocoons will be either thrown to the surface where the pupæ within will perish, or be buried so deeply that the moths escaping later will not be able to work their way out of the soil. The cocoons are usually found a foot or more away from the vines, a fact that enables the cultivator to reach most of them without the necessity of working up entirely to the vine, which is a difficult thing to do where some methods of pruning are practiced. As a matter of course, the cultivation will give the vines increased vigor, enabling them more readily to withstand and overcome the attacks of root-borers and other insects.—(W. Va. Bul. 110.)

*The California Grape Root-Worm.**—This is an insect that attacks both the roots and the growing parts of the vine above ground. It has been known to attack the leaves of the vine in this State for a good many years, but until a year or two ago it was unknown as a root feeder. It is similar in its life history and mode of attack to the well-known grape root-worm of the Eastern States, which is one of the worst pests that the vineyardists there have to wage war against. Our species has been doing considerable damage during the past two or three years, and it promises to be an important enemy of the vine in California.

While the insect has occurred on vines in the State for the last thirty years it seems not to have spread so rapidly as might have been expected, judging from the experience with the same insect in Europe and its related species in the Eastern States. It is difficult to explain just what may account for this.

Since the greater part of the insect's life is spent in the ground, it is in this stage that conditions would be most likely to influence its progress. Such conditions might be found in the kind of soil, the cultivation of the soil, the variety of vines and the great depth of the root systems in some of our drier sections. Again, the true importance of the insect's work has never been appreciated in the State hitherto, since it has been known as a leaf feeder entirely. Vines, therefore, may have shown a general unthriftiness due to its attacks, but because the root infesting habits of the larvæ were unknown the trouble may have been assigned to other causes.

The young larva upon hatching from the egg makes its way to the ground almost immediately. It may crawl to the ground, as we infer from finding them pretty well scattered down the trunk of the vine, or they may possibly in many cases simply drop to the ground.

As soon as the larvæ reach the roots of the vine they begin feeding, and it is generally the smaller rootlets that are first attacked, although we have found young larvæ around roots of considerable size. These smaller roots may be eaten off entirely. The larger roots are injured by the larvæ gouging out long strips of the bark, which sometimes take almost any direction, but on the roots of medium size these strips are usually eaten out in a direction parallel with the axis of the root, or in a spiral direction. The frass or eaten bark is left in their paths and is characteristic of their injury. The furrows made are from one-tenth to one-fifth of an inch wide, and in cases of severe injury all the bark may be eaten away from the roots. This feeding is continued from the time they hatch in the spring until the vine becomes dormant in the fall.

There are two forms of the adult beetle occurring in the State, one being black in color and the other mostly brown. There is considerable differences in the size of different specimens, and particularly in the sexes—the males being much smaller. On an average they will measure about one-fifth of an inch in length.

* See page 321, for illustration.

Many of the pupæ may be destroyed by deep cultivation for a radius of two or three feet about the base of the vine. The beetles may be killed by a strong arsenical spray, or by jarring into crude oil, or otherwise captured as they are shaken from the vine.—(Bul. 195, Col. Agr. Exp. Sta.)

The Grape Phylloxera.—The phylloxera occurs normally in four forms, which have been called by Victor Mayet: 1. The gall insect, or form of multiplication; 2. The root insect, or form of devastation; 3. The winged insect, or form of colonization; 4. The sexual insect, or form of regeneration.

The gall insect lives upon the leaves, and is the commonest form on the wild vines in the native habitat of the insect. It rarely or never occurs in California. In Europe it is found often upon American and rarely upon European varieties. It causes little swellings or galls upon the leaves and younger parts of the vine, which, though sometimes very numerous, do little permanent injury. The chief danger from the gall form is that it multiplies with astonishing rapidity and migrates from the leaves to the soil. Here it attacks the roots and gives rise to the root form, which is the form of devastation, the one which finally destroys all the vines it attacks which are non-resistant. Every insect of the root form which reaches maturity lays about twenty-five or thirty eggs, each of which is capable of developing into a new egg-layer needing no fertilization. As there are from five to seven such generations during the year the increase in numbers is extremely rapid.

The most satisfactory method of combating phylloxera is the use of resistant vines, because it is applicable to all conditions and is the most economical in the end. A resistant vine is one which is capable of keeping alive and growing even when phylloxera are living upon its roots. Its resistance depends on two facts: 1st, that the insects do not increase so rapidly on its roots; and, 2d, that the swellings of diseased tissue caused by the punctures of the insects do not extend deeper than the bark of the rootlets and are sloughed off every year, leaving the roots as healthy as before.

Though high resistance to phylloxera is essential in a grafting stock, there are other characteristics equally necessary. The Rotundifolia (Scuppernong), which has the highest resistance of any vine, is useless as a stock on account of the impossibility of grafting it with any Vinifera variety. This is due to a lack of affinity, which means a lack of similarity in structure and composition between the tissues of the stock and those of the scion. This lack, in extreme cases, results in an imperfect and temporary union, but when not excessive, only a slight decrease of vigor. The affinity is not perfect between Vinifera varieties and any resistant stock, but in the case of Riparia and Rupestris is generally sufficient to insure permanence to the union, and the slight decrease of vigor consequent often results in an increase of fruitfulness.

The Strawberry Root-Louse.—Whenever numerous bare spots are found in a strawberry bed, and the remaining plants are more or less unhealthy, failing to mature fruit properly, the owner will do well to examine it for the root louse. If the bed be infested, openings of ants' nests will usually be found very numerous and large numbers of small brown ants will be seen among the plants. Upon pulling up an infested plant many of the roots will be covered with clusters of the little black plant lice.

The root lice, or aphids, found on the roots during summer and early fall are very small insects only about one-twentieth of an inch long. They are of a deep bluish-black color, and somewhat pear-shaped, tapering toward the head. There are usually four generations. The pest may be spread in three ways: (1) by the aphids or eggs being introduced upon the plants in setting the beds, (2) by the spread of the winged lice, and (3) by being transported by ants. Undoubtedly the species has been most generally spread by infested plants, either from the nursery or from old beds.

It is evident that land infested with aphids should not be immediately replanted with berries, for through the care of the ants, a few eggs or viviparous females are very apt to survive either in ants' nests or upon stray plants growing around the border of the field. If it is desired to replant berries after a single year's rotation the land should be put in several crops which require constant cultivation. Corn and melons are commonly infested with aphids which are attended by ants, and these crops should therefore never be followed by strawberries, where there is any possibility of the root-louse.

As the aphids and their eggs are readily transported on young plants it is of the utmost importance that the plants be secured from sources known to be free from the pest, or, if any doubt exists on this point, that they be thoroughly disinfected by the dipping of the plants in a tobacco decoction or by fumigation with hydrocyanic acid gas as for San Jose scale.—(Bul. 49, Del. Exp. Sta.)

The Strawberry Weevil.—Just before the blossoms of the strawberry expand they are attacked by an insect which severs them from the stem. This insect is the strawberry weevil, and the severing of the buds is accomplished by the female in the process of oviposition. The weevil first deposits an egg in the bud and then punctures or cuts the stem below it so that in a few days it drops to the ground. Within the severed bud the larva hatched from this egg develops, and transforms to the pupa and afterwards to the beetle.

The strawberry weevil measures only a tenth of an inch in length, and is provided with a slender, slightly curved snout, about half as long as the body, to which are attached its jointed antennæ. The color varies from nearly black to dull red, and each elytron or wing-cover is ornamented just behind the middle with a dark spot surrounded with whitish pubescence.

The presence of the weevil in strawberry beds is manifested by the decreased number of blossoms and the severed buds and stems, the diminutive size of the beetle protecting it from general observation. Nor is the destruction of the buds likely to be noticed until some time after the insect has been at work. Hence it happens that injury, even over wide areas, is often attributed to hail, frost, or to some other cause than the right one. Appearing, as the insect so often does, in great numbers almost from the outset, its injuries are severe even in seasons when only a moderate percentage of a crop is lost, because the blossoms chiefly injured are the earliest, and consequently the shortage is largely in the early fruit, or that which commands the highest market price.

Injury, as already stated, is due to the work of the female in the course of oviposition. Selecting an unopened, nearly mature bud she perforates with her beak the corolla or outer husk and turning about deposits in the hole thus formed a single egg. She then crawls to the pedicel or flower-stem just below the bud and with the microscopic but scissors-like mandibles at the extremity of her beak deliberately punctures or cuts it in such manner that the portion containing the bud hangs by a mere shred of the epidermis and soon afterwards falls to the ground.

The object attained by the parent insect in puncturing the stem is twofold: (1) The development of the bud is arrested, and its outer envelopes of sepals and petals remain folded, thus retaining the eggs or growing larvæ of the insect and the pollen on which the latter feed; (2) the bud falling to the ground is kept moist, whereas if permitted to remain upon the stem it would eventually have become so dry as to prevent the development of the insect within. Ordinarily a single larva inhabits a bud, but in exceptional cases two individuals may develop in one bud.—(Cir. 21, Rev. Ed. U. S. Dep. of Agr.)

Owing to the difficulty of contending with the insect when once it has invaded a strawberry bed, it is necessary to have recourse to preventive measures. A nearly perfect preventive consists in covering the beds. This covering, which may be of muslin or some similar light material, if properly applied will not only exclude the weevil and other noxious insects, but will secure immunity from frost and is moreover a positive benefit to the berries, which ripen a week or ten days earlier and are superior also in quality and size. Whatever covering is employed should be put in place over the beds at least a week before the appearance of the first blossoms and may be safely removed as soon as the first berries are ready for market. Pistillate plants, or those which produce no pollen, require no such protection.

It is obviously unsafe, in districts where the weevil is known to be abundant, to trust entirely to staminate varieties of berries. It is advisable, therefore, to grow chiefly pistillate varieties and just as few staminates as are necessary for the purpose of fertilization. The insects, when they become abundant, will mass themselves upon the staminate plants, where they may be destroyed by spraying and similar measures.

The most satisfactory method of securing freedom from injury by the strawberry weevil is to plant very profuse-blooming varieties, and many have agreed that the following, in the order named, are the best that have been tested to secure this end: Rio, Superior, Tennessee Prolific and Gandy.

In the same manner that the rows of staminates used for fertilization constitute a protection for the other rows, certain varieties, particularly such as bloom early, may be used to protect later-blooming plants. One of the best for this purpose is the Charles Downing, as it blooms early and its blossoms are exposed to the sun. By laying out beds with Downings or other early staminates on the sides that experience has shown to be most susceptible to attack—*e. g.,* in protected sunny spots or near woodland in which the beetles might have hibernated—the insects will be attracted from the other portions of the beds and can be the more readily controlled by spraying with the arsenicals.—(Cir. 21, R. E., B. of E. U. S. Dept. of Agr.)

The Strawberry Leaf-Roller.—This leaf-roller seems to be of European origin, and is one of those species which in its native home is not seriously injurious, but in its new surroundings finds conditions to its liking and frequently outruns its natural checks. At the present time it extends from Canada to Virginia and probably even farther south, and westward to the Mississippi Valley, very often in harmful numbers. It is, in the adult stage, a small moth, measuring with expanded wings about three-fifths of an inch. Its color is light reddish brown, the forewings streaked with wavy darker brown and white lines as shown in the figure. When the wings are folded and the insect is at rest, the dark area at the base forms a somewhat conspicuous deeper brown patch on the middle of the back. The hind wings are of a soft dark smoky gray, and both wings have long fringes. The moths fly readily during the middle of the day and run rapidly on the leaves, diving to the under side or into a fold so quickly that it requires close watching to follow their movements. They do not ordinarily fly very far where food plants are abundant, but where they are plentiful, some of them find their way to considerable distances, infesting new fields where clean plants were set out.

This moth makes its appearance in the strawberry fields in early May. The insects mate soon after their appearance and egg-laying begins at once. The eggs are pale green, almost like the underside of the strawberry leaf in color, round or slightly oval, much flattened and about as large as the little meshes in the netting of the half-grown leaf.

Larvæ hatch from these eggs in from five to seven days, and at once make their way to the upper surface. At this time the minute creatures are light green in color, with a proportionately large head and rather long hair. When first noticed they are about an eighth of an inch in length and are feeding on or along the midrib of a leaf or lobe or, sometimes, on a larger leaf, along one of the larger veins toward the edge of one side. For a day or two the minute caterpillar feeds thus without protection, gnawing into the vein or alongside so as to weaken the tissue, and then it begins to draw the upper surfaces of the leaf or lobe together by means of fine silken threads, until there is a complete fold that forms a shelter for its maker. It feeds continuously within its shelter, and improves it by making the fold more complete and more secure, and sometimes actually making a roll of an entire leaf.

Any method that will get rid of the old leaves on a strawberry patch in late fall will serve to destroy the pupæ ready there for hibernation, and no old patch that is to be abandoned should be allowed to remain on the ground over winter. Just as soon as such a patch is no longer useful it should be turned under as thoroughly as possible to destroy all the insects then feeding on the foliage.

In bearing patches injury can be completely prevented by a single, properly timed spraying with arsenate of lead, at the rate of from four to five pounds per 100 gallons of water. The important point is the time of application. It is quite obvious that any spraying after the larvæ have folded the leaves must be ineffective because the material simply cannot reach the larvæ in their concealed feeding places. Applications made too early would permit the development of foliage after the poisoning, and would leave uncovered leaves to be injured by the larvæ. Spraying should be done within a week after the moths are noticed in the field, and just about the time when they are becoming abundant.—(Bul. 225, N. J. Agr. Exp. Sta.)

The Strawberry White-Fly.—These white-flies are very small, four-winged creatures, which, when at rest on the underside of the leaf, look like miniature moths. This impression is heightened by the white mealy powdering that covers the surface of the insect, and is responsible for one of its common names.

These flies occur at intervals throughout the summer from May to September, and lay their small, shortly stalked eggs on the undersides of the leaves. They hatch in about ten days into active yellowish larvæ that very much resemble those of scale insects. As in the case of scales, this active stage is short, and in a short time the little creatures settle down and begin to suck the plant juices.

Then their resemblance to the scale insects becomes yet more marked for a time; they lose antennæ and legs and are as much fixed to the plants as any scales. As they grow, this outside case or scale becomes fringed with waxy filaments, and honey-dew is excreted. When the insects are abundant this honey-dew dropping to leaves below may form a sticky varnished surface, upon which a black soot fungus develops.

As a result the foliage loses vitality and dries up or decays, seriously injuring or destroying the plants, especially if they be young or small. The total period of development from egg to adult is from thirty to thirty-five days under normal conditions, and there may be three broods during the year.

The insects are rarely abundant enough to do severe injury on large plots, and usually it is only about midsummer that they are abundant enough to attract even local attention. The normal weather conditions are unfavorable to their development, and it is only in droughty periods that they seem to become dangerous.

In the active larval stages this white fly succumbs readily to any of the contact insecticides at moderate strengths, and the adult is not much more resistant, though this is harder to reach, because it flies readily if not very strongly. As against the nymphs or scale-like stages, kerosene emulsion diluted with twelve parts of water seems to be most effective; but it must be applied with a bent nozzle so as to hit the underside of the foliage. If adults are flying when the application is made, a fine spray is desirable, for this, if applied with sufficient force, will fill the air above and around the plants with a fine mist that will hit and disable many of the insects on the wing. Whale oil soap suds, one pound in six gallons of water, has also been used with good effect in the same way.

A badly infested patch should never be used as a source for plants to make a new bed, unless these plants are first fumigated with hydrocyanic acid gas.—(Bul. 225, N. J. Agr. Exp. Sta.)

White Grubs (Larva of June Beetles).—White-grubs are larvæ of May-beetles, or June bugs, the clumsy brown beetles about an inch long, that fly to light and often into houses in late May and early June. These beetles lay their eggs in grass lands or land covered with vegetation to form a sod of some kind. They hide during the day just below the surface in such grass or weed-covered land, and do not by choice frequent cultivated land except to feed on such foliage as may be attractive to them. Old sod or land left fallow for some years becomes continually worse infested as brood after brood of eggs are laid in it. From the eggs laid in June the small white grubs hatch in July and begin feeding on the finer rootlets. They do not grow very much that first season and are less than half an inch long when winter sets in and they retire below the ordinary frost line. The next season they feed from May to October on the roots of the plants, usually about three to four inches below the surface, and when winter sets in again, they are an inch in length and stout in proportion. The third summer they complete their growth in July, and, at about six inches below the surface, form an oval, smooth cell in which they change to the pupal stage. This pupal stage lasts about a month and gradually hardens into the adult or beetle, which is in the cell, fully formed but not fully colored, in September.

It will be readily seen that after a plot is in sod for three years the ground will be full of grubs in all stages of growth, and that every year thereafter the number of full-grown larvæ is likely to increase. When such a sod is turned under and another crop is planted, that crop almost inevitably suffers, for the insects deprived of the mat of roots upon which they have been feeding, concentrate on the small number of plants and the result is fatal.

We have no satisfactory insecticides to reach underground insects. They have their natural enemies among the vertebrates—birds, moles and the like—as well as insect parasites and fungous diseases, but these do not keep down the insects to harmless numbers. It is in farm practice that our hope of control lies. In the first place keep land in grass or fallow as short a time as possible consistent with the desired rotation and never allow a field to become badly overrun by weeds early in the season if it can be avoided.

In case it is necessary to use an old sod, plow in early fall. Although the white grubs change to beetles in September they are at that time soft and helpless, and if turned up to the surface they are unable to find their way back and will perish. If still in the pupal stage this will perish without being able to transform. Plowing in mid-September will be best for this purpose, and, if desired, a cover crop can be put on. This process will kill the brood ready to transform, but will not kill the younger grubs yet in the ground.

To reach these, turn hogs, or chickens, or turkeys, or all three into the newly plowed field, and they will get the great majority of all the grubs in the field. Indeed, in an old sod, if a few shallow furrows be run through it and hogs turned in, they will from the start thus given them root through the entire field, and get all but a small percentage of the grubs. In localities where white grubs are known to be troublesome, every sod field to be put into strawberries should be treated in this way to avoid injury.

Where white grubs are actually in a strawberry bed, there is nothing to do but to dig them out wherever a plant shows injury. In such a case it is well also to let the field run moderately to weeds to distribute the feeding, while not enough to attract beetles to lay eggs.—(Bul. 225, N. J. Agr. Exp. Sta.)

Ground-Beetles Eating Strawberries.—The beetles evidently attack the fruits primarily to get the seeds, and considerable of the pulp adheres to the seeds when they are removed; but sometimes the beetles eat much of the pulp also. Ripening berries which they have fed upon often soon begin to rot, and they ruin for any purpose every berry they attack. The favorite haunts of the beetles are under stones and rubbish on the ground, hence the usual mulch on a strawberry bed forms an ideal lurking place for them.

In England, Miss Ormerod has shown that even when feeding on strawberries, the beetles do not lose their carnivorous appetites, and may be attracted by meat. Some English strawberry growers report that they almost entirely destroyed the beetle pest by sinking into the ground to the level of the surface a lot of cheap basins or dishes and then keeping these traps baited with pieces of meat (lights) and sugar water; in dry weather they often caught half a basinful in one night! Another grower caught enormous numbers of the beetles by pouring about half an inch of tar in the bottom of the basin traps. Doubtless any kinds of spare waste meat or fish would prove equally attractive to the beetles, and some cover such meat with thick sacking and then collect by hand those which gather around and under this bait. These trapping methods involve considerable trouble and expense but one had better spend $25 in thus protecting a $250 crop of strawberries which the beetles are capable of ruining in a few days.—(Bul. 190, Cornell Agr. Exp. Sta.)

THE BLACKBERRY AND THE RASPBERRY INSECTS.

The Red-necked Cane Borer.—The parent of this borer is a small, slender beetle, not exceeding one-third of an inch in length, somewhat tapering toward the end of the body, bronze brown in general color, but with a coppery red or brassy neck or thorax, which makes it easily recognized and gives the name to the species. It is found during bright, sunshiny days in late May, all of June and half of July, on the upper surface of the leaves, eating little round holes, but not doing any perceptible injury in this stage. The beetle is quite active and flies readily, or, if surprised, it will fold its legs and drop to the ground, remaining quiet until the danger is over.

Early in fall and during the winter the canes will often show a usually rather symmetrical, not very abrupt, nor very great swelling. At its worst it is rarely more than one-third greater in diameter than the normal cane, and quite frequently the swelling is very slight. These galls may be almost at the base of the cane or they may be anywhere from two to even three feet above ground. Usually only the main canes are infested, but not infrequently the more vigorous laterals are also attacked. From one to four of these swellings may be found on a single cane. The infested shoots may throw out leaves or even blossoms in spring; but they rarely ripen fruit and invariably die during the season. If late in the fall, or early in spring, a stem be split through the swelling, it will be noticed, first, that the wood itself is not at all involved in the abnormal growth; but that the bark alone is the seat of the trouble. It will be seen, further, that there are hard, granular, brown patches throughout this swollen bark, and by careful peeling it appears that these are sections through girdling channels of the same character. The stem may be thus girdled several times, and the girdlings eventually cause the death of the cane; sooner or later, in proportion to their number and size. It will further appear that the pith also shows a brown track and, anywhere from one to six inches above the swelling, will be found a slender white larva from five-eighths to three-quarters of an inch in length, with an enlarged head and brown jaws. This is the culprit that has caused the mischief.

The mode of checking and avoiding future injury by this species is obvious, and requires only a little additional work when trimming. As early in the spring as may be, and certainly by the middle of April, the canes should all be carefully examined and cut away below the galls. If these are at or near the surface of the ground, the entire cane must be sacrificed. It might possibly bear some fruit; but it would certainly mature a beetle which would destroy a dozen other canes, and this would be poor economy. As the plants are all pruned each spring in any case, it means simply a little more care and judgment exercised in the work at a somewhat greater expense of time. After the cutting, all the twigs and other rubbish should be raked out, and at once burned. If the cut canes are left in the field, the beetles will mature as well as if no cutting had been done, and nothing is gained. Every gall should be cut out and destroyed before the beginning of May. This will prevent maturing of the beetles, and the field will be exempt from further injury unless specimens come on from other sources. This fact makes it important that growers should co-operate in the work, and that, as already suggested, some means should be provided to compel all engaged in blackberry culture to prevent their land from becoming a nuisance to their neighbors.—(Sp. Bul. N. N. J. Exp. Sta.)

The Giant Root Borer.—Besides the crown borer, the blackberry also harbors in its roots an enormous beetle larva, between two and three inches in length, white in color, with strongly-marked constrictions at the segments, a distinct enlargement anteriorly, and a small, smooth, brown head, with stout, dark-brown jaws. The parent of this larva is a long-horn beetle.

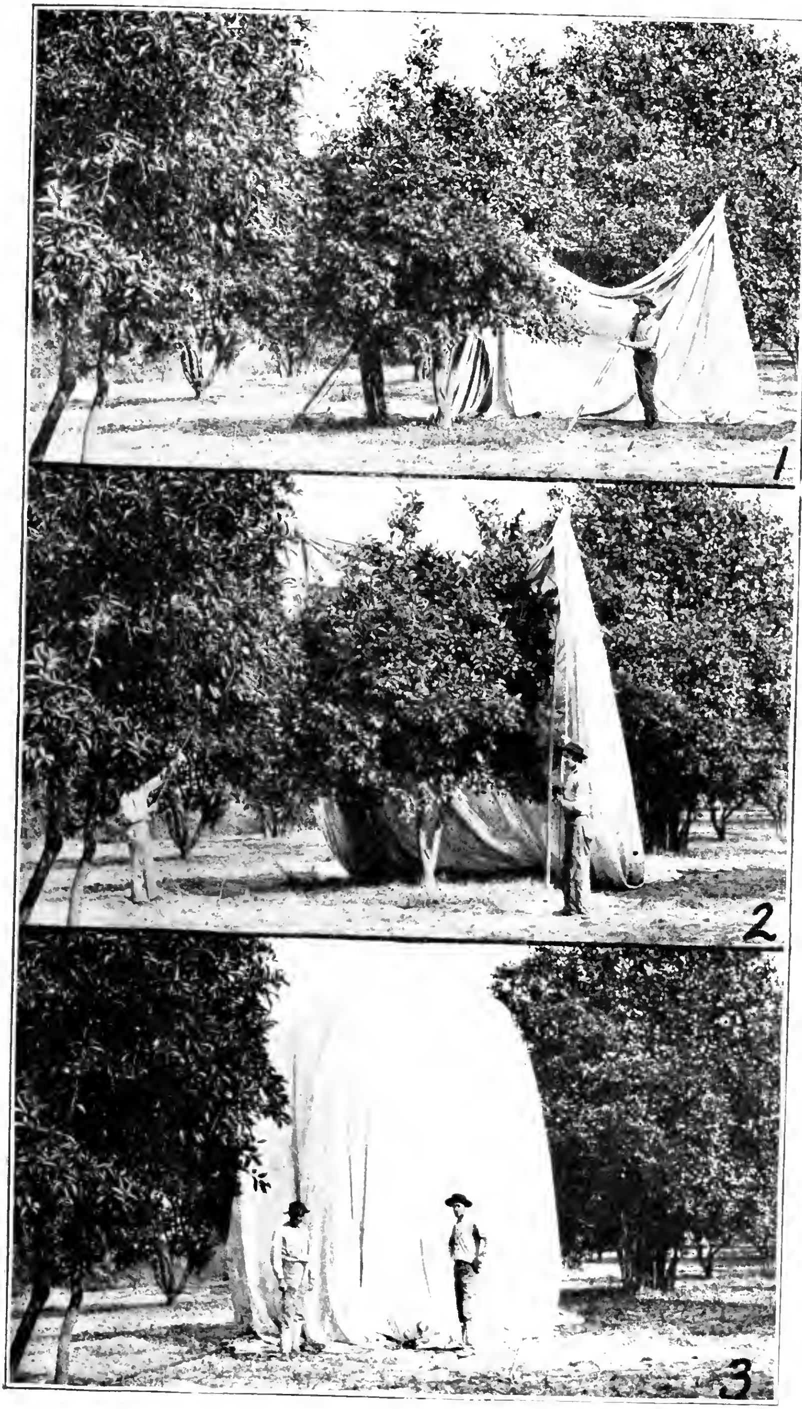
The pupa is formed in June or early in July, and the beetle makes its appearance at about the middle of the latter month. It is rarely seen, even where not uncommon, and flies principally at night. Fortunately this borer is comparatively scarce; but where it does occur, signs of its work are readily observable. It lives in the large, woody portions of the main root, in which it bores huge channels, and the sudden dying off of several canes in a hill is a certain indication of its presence. Rarely only a single cane will be affected, and then if a crown borer is not found, the presence of this insect in the main root is almost certain.

As with the preceding, the remedy is mechanical. Whenever signs of its presence are noted, it should be at once sought for and destroyed. It is more common in old, carelessly-kept fields and, where numerous in such places, it will be better to grub out and burn all suspected stocks, and replace them by new plants. This should be done before the middle of June, to prevent the maturing of the beetles.

The Raspberry-root Borer, or the Blackberry-crown Borer.—The parents of this borer are of the clear-winged moths belonging to the family *Sesiidæ* and the species is a near relative of those producing the peach and squash borers. In appearance in the field it is not unlike a wasp or hornet, and may be readily mistaken for one or the other by a casual observer.

The body of the insect is rather more than half an inch in length, black, the thorax with narrow yellow markings, the abdomen with six distinct yellow rings and a tuft of yellow hair near the base. The legs are also clothed with yellow hair and scales. The wings expand about one inch, are narrow, transparent, and with a bronze-brown margin. The primaries or fore-wings have also a narrow, transverse, brown band about one-third from tip.

The moths make their appearance in the fields late in August and early in September, and soon after begin ovipositing. A single egg only is laid on the cane, near the surface of the ground, or even a little below. The young larva, when hatched, immediately eats through the bark and begins work at the base of the stalk, where it joins the crown or main root, confining itself largely to the sap-wood. The young larva is yellowish white, usually with a faint reddish tinge. It attains a length of from one-quarter to one-third of an inch during the fall, and has at that time eaten about half through the cane, sometimes entering the pith and boring up into the stem for a short distance. Usually, at the seat of injury there is a morbid enlargement of the cane, and this gives room for the pupal cell. The pupa is small in proportion to the full-grown larva.



COVERING SMALL TREE WITH BELL OR HOOP TENT [illegible]

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No applications to destroy the larva can be recommended and, as in the case of the red-necked borer, the remedy is mechanical. After the plant has made a start in the spring, and the dead canes are readily noticeable, every infested hill should be examined and the borer, which is almost certain to be found at the base of the dead wood, should be destroyed. When cultivating or topping new growth, if a shoot gives sign of wilting, it should be at once examined at the crown and the borer destroyed. They are much more certainly found at the base of the new shoots, because these show the effects of their presence almost immediately. By persistent and careful work, the development of imagos can be almost entirely prevented, as each borer is exposed for two full seasons of cultivation and field-work.—(Special Bul. N, N. J. Agr. Exp. Sta.)

The Raspberry-Cane Maggot.—This pest is a fly. It lays its eggs on the young shoots of the raspberry and blackberry plants. When the eggs hatch the maggots enter the young shoots, tunneling down them two to several inches, and then girdle them. Girdled blackberry shoots seldom die; girdled raspberry shoots usually do. When the shoots live the maggots die. The maggots work in the dying and dead shoots for a time and then pupate. The pupæ remain in these canes during the fall and winter, emerging in the spring. To combat this pest, cut or break off all infected shoots two to three inches below the girdle early in the summer and burn them.

By the time the canes are two or more inches in height adult females appear; they lay their eggs on or near the tips. Later in the season, after the canes become branched, eggs are deposited on the tips of laterals. When these eggs hatch, the maggots enter the canes and girdle them near the tips. The part above the girdle wilts and, after a few hours droops. The canes are easily broken off at the girdle.

When the raspberry, Logan berry, and dew-berry are girdled the portion above the girdle soon dies. At the point of girdling the stem becomes a light-blue color; soon the color runs up the stem and the discolored shoots and tips of the canes become very conspicuous.

As the pest spends the greater part of its life inside the raspberry canes it is impossible to combat it with a spray. Both the maggot and the pupa are well protected by the tissues of the dead canes, and it is not practicable to attempt to destroy the eggs or adults. The only known method of combatting them is to collect and destroy the infested canes about the time the maggots transform to pupæ.

It is not a difficult task to locate the infested canes, as they are easily recognized by the wilted and drooping tips which, later, become a deep-blue color. One or two trips through the yard are sufficient to collect all of them. It is best to do this work late in May or early in June, as by this time all the eggs have hatched and the maggots have girdled the canes. The maggots are usually found below the girdle at this time of the year; for this reason cut or break off the young shoots two or three inches below the girdle in order that the young maggots may not be left in the stumps of the canes. —(Bul. 62, Wash. Agr. Exp. Sta.)

The Raspberry Byturus.—The cause of the injury is a small brown beetle, belonging to the same family as the buffalo carpet moth and the museum pests. This one, however, has the unusual habit of confining its attack to living plant tissues, instead of feeding on animal fibre and tissues as its near relatives do. This small brown beetle, the Raspberry Byturus, feeds upon the young leaves and buds of the raspberry, and the larvæ develop in the head upon which the berry is borne, causing the affected berries to ripen earlier, and this tends to make them small and unfit for market.

Its injuries are severe, but these are usually confined to small and somewhat local areas. It probably has some insect enemies which hold it in check, in most cases, as it seems to disappear after a few years of abundance, during which it inflicts severe injury on red raspberries. The beetles are pale yellowish-brown in color when they first emerge, but get much darker in a few hours. They often fly to the tender leaves and buds of the raspberry bushes before they have assumed their normal color, and immediately commence feeding on the tender leaves, and on the under sides of lone buds, and on the inner contiguous sides of clustered buds. In the latter case where the buds are touching each other, they do the most damage, as they often eat out the sexual organs of all the adjacent buds in a cluster. Most of the tender leaves are partly skeletonized, and sometimes completely so, when the beetles are plentiful. These worms are plump and cylindrical, slightly tapered at each end, and nearly one-fourth of an inch in length when full grown. They are white, each segment having on the back a broad, pale, tawny yellow band, occupying more than half its surface, and being also furnished with a few short, erect, whitish hairs.

Spray heavily with arsenate of lead just before the emergence of the beetles and this will destroy most of the beetles and materially lessen their injury to the flower buds. In connection with this, thorough cultivation late in the fall, close up around the bushes, will destroy many of the pupæ, or expose them to the freezes and thaws of winter, thereby causing their destruction. Spraying with kerosene emulsion is only to be recommended where the beetles are already very numerous, and the spraying with arsenate of lead has been deferred until after the beetles have appeared in large numbers; even then, the arsenate of lead will be fully as effective and last for a much longer period, but in extreme cases the two may be used together. Bordeaux may be added for fungous diseases, and will help to hold the arsenate of lead on the foliage and buds, making the spray slightly more efficient than if arsenate of lead were used alone.—(Bul. 202 Ohio Agr. Exp. Sta.)

The Tree-Crickets.—Many times one finds long rows of punctures on the sides of raspberry and blackberry canes, and also on the new growth of peach trees. When such a twig is split along the row of punctures, each hole is found to contain an egg, the egg of a tree-cricket. The rows vary in length from one to several inches, and sooner or later usually cause the twig to split open, weakening the twig if not killing it outright. The cricket that causes all this trouble is a delicate little creature, light colored, sometimes with dark markings, and provided with good sized wings. It is perfectly harmless except for the habit of placing its eggs in twigs in the autumn. In fact it is said to feed largely on plant-lice and therefore to be our friend. The only pratical method of combating these insects is by cutting out the affected canes and twigs and destroying them by fire. If not at all numerous, they may safely be ignored.—(Bul. 24 Mich. Agr. Exp. Sta.)

The Currant Span-worm.—Unlike the larvæ of the imported currant worm, those of the span worm are measuring-worms or loopers, sometimes called inch-worms. All are familiar with caterpillars of this class. The currant span-worm often comes in large numbers, and devours the foliage very rapidly. The caterpillar, when full grown, is marked with three longitudinal yellowish stripes and by several spots on each segment. The pupal stage is passed under the surface of the soil, and the delicate, yellowish moth lays the eggs in summer for the brood of larvæ which will come out next spring about the time that the foliage becomes well grown. This insect works also on gooseberry. There is but one brood each year.

When the larvæ are noticed early before the fruit is more than just set, paris-green applied in the ordinary way, will kill them very nicely. After the fruit gets started, use hellebore in place of paris-green, because it is much safer.

The Imported Currant-worm.—The common currant-worm is the larva or false-caterpillar of a saw-fly. Saw-flies belong to the same order as the wasps, but in place of stings, they are provided with saw-like implements with which they are enabled to cut slits in the foliage or bark of vegetation. They are mostly small, thick-waisted creatures with four wings, the color being often black or yellowish.

The saw-fly under consideration, lays its eggs in rows along the ribs of currant or gooseberry leaves where they absorb water and become swollen, afterwards hatching into small, whitish false-caterpillars, which turn green after a time. Later, many black dots appear on the body, and just before they are ready to spin up in a cocoon, they change once more to green with yellowish extremities. The larvæ of saw-flies may always be distinguished, from those of moths and butterflies, by the number of feet, there being always six true, jointed legs and twelve to sixteen false legs; while true caterpillars with very few exceptions have only ten false legs.

When full grown the larva spins a cocoon, usually in rubbish near the base of the plant, although they may go beneath the surface of the soil. The cocoon is oval in form and thin, being papery in texture. There are two broods a year but they are not well defined. The adults come out at various periods, necessitating a repetition of the measures required to kill the larvæ. The time honored practice of dusting with hellebore will ordinarily prove sufficient if the hellebore be fresh. After the fruit has been picked, arsenites may be used to advantage. See directions for using paris-green.

The Native Currant Saw-fly.—Another species of currant-worm which is a native of America is sometimes met, especially in the North. It occurs somewhat later than the imported species and the larvæ are green. The same remedies as those used against the imported species will apply.

The Currant Aphis.—Green lice on the under side of currant leaves, causing the leaves to turn reddish in color and to have an irregular surface. Spray with kerosene emulsion or whale-oil soap solution. This spray kills only by coming in contact with the lice, therefore direct it against the under side of the leaves.—(Bul. 24 Mich. Agr. Exp. Sta.; Bul. 51 Mont. Agr. Exp. Sta.)

Imported Currant-borer.—The currant and gooseberry are often attacked by a borer that works in the center of the branch, tunneling down quite a distance and interfering seriously with the development both of the foliage and of the fruit, and eventually bringing about the death of such tunneled wood. Stems containing borers show the presence of the invader by wilted and stunted foliage early in the season. The larvæ after feeding on the pith and central part of the stem until autumn, pass the winter in the tunnel. In the spring when the plant starts to grow the larvæ are awakened to new activity and quickly complete their growth. Before changing to pupæ they eat their way almost through to the outside, plug up the hole loosely and retire. The pupal stage is entered upon and in June the adult moths come out to the open air. In this stage the insect is very beautiful, being a little less than half an inch long, slender, and brilliant black and yellow in color. The wings are only partially covered with scales, the uncovered part being transparent. For this and other reasons they are placed among the group of moths known as clear-wings. They so closely resemble wasps that one hesitates to handle them without careful examination. The larva possesses feet like those of most moths.

When the foliage commences to expand, the mutilated stems can be distinguished by the sickly appearance of the leaves. Cut out all tunneled stems below the lowest part of the tunnel, and burn them. If this practice be constantly followed up, the bushes can be kept fairly free from this borer.

The Native Currant Borer.—Curiously enough, we have two borers working in the currant, one belonging to the clear-winged moths, imported from Europe, and the other a native insect belonging to the beetles. The adult beetle is from three-sixteenths to one-fourth of an inch long, brown in color, with the posterior half of the wing-covers darker than the rest of the body, and with two whitish spots on each wing-cover. The larvæ or grubs of this beetle are footless, and work very much as do the imported borers, except that usually several work together instead of singly as in the case of the other. The same remedies apply as in the case of the imported species.—(Bul. 51 Mich. Exp. Sta.) See Apple Insects.

INSECTS INJURIOUS IN CRANBERRY CULTURE.

The Blackhead Cranberry Worm.—This is perhaps the best known and most uniformly injurious of all cranberry insects and is locally known as the vine worm in Massachusetts and as the fireworm in New Jersey. As a larvæ (worm) it is a deep, rather velvety, green, slender little caterpillar, not over half an inch long when full grown, and with a shining black head and neck. The adult is a small moth or miller with narrow, dusty-brown wings that measure less than half an inch when expanded and seem much smaller because they are so slight. More closely examined the fore wings will be found to have alternate light and dark gray-brown shade bands, obliquely arranged. The moths first appear on the bogs in early June, continuing until nearly the end of the month, and again late in July, continuing into August, when they disappear for the season.

These eggs are flattened, disk-like, and less than half the size of an ordinary pin head, but their bright yellow color makes them easily visible against the green of the leaf, even without a magnifier. There they remain throughout the winter, whether the bog be dry or flowed, and the little caterpillars hatch from them in spring as soon as the temperature reaches an average of about 60 degrees. Many of the eggs perish during the winter, but where the vines are uncovered in sheltered spots they hatch out little worms about the time the vines themselves are making a start. For a day or two the worms nibble on the under surface of the old leaves or may even burrow into them and then make their way to the tip of an upright, where they spin together the edges of the new leaves.

The bog at the beginning of July shows very plainly the effects of the insect's attack in brown tips that are everywhere noticeable; and every brown tip at this time means a barren upright. Next the leaves drop and the burnt appearance disappears for a few days, but this is only to give way to another series of spun-up tips which resemble those of the early brood, but with a difference. The vines are now in full foliage, full of buds and almost ready to bloom. Unlike those of the first brood, the worms of this second brood are not content to spin up only a single tip; they gather into their web everything within reach. Two or three sprays with all their buds may be included and every chance for fruit destroyed. In fact, the buds, flowers, and very young berries are eaten by preference, and the injury to the crop is out of all proportion to the amount of plant tissue actually devoured. So, also, instead of eating up a leaf entire, the worms take a few bites here and there until, toward the end of July, the bog appears as if it had been burnt over, justifying the term fire-worms for the insects.

The Yellowhead Cranberry Worm.—The common name here used describes the most conspicuous difference in the larval (worm) stage from the preceding species, and is employed in preference to the term vine worm under which it used to be best known in New Jersey. In this species the eggs are not on the bogs during the winter. On the contrary, the moths themselves hibernate in any shelter they can find—in cranberry houses, barns, or other buildings; under bark or bark scales on trees, and in numerous other places where they may find protection from the direct influence of the weather. At this season the moths are uniformly slate gray, inconspicuous, much broader winged than the moth of the blackhead worm, apparently much larger in every way. They are on the wing as soon as vegetation starts in spring and are ready to lay their eggs during the latter part of April and early May. They prefer cranberry if they can get it; but if not, make a shift with huckleberry or some allied plant, or even with apple. Wherever cranberry vines run up on the dams above the water line, or are otherwise not submerged, eggs are laid on the underside of the leaves. These eggs resemble those of the blackhead species so closely that, except for their fresher, brighter appearance, no differences can be observed even with a good hand lens. By the middle of May in New Jersey, and perhaps a little later in Massachusetts, all the moths have disappeared. This habit is an important one from the practical point of view and gives in some localities practical control of the insect. The eggs hatch in a week or ten days—depending much upon the weather—the worms make their way to the tips and spin together the terminal leaves, exactly as do those of the preceding species. The yellow head is practically the sure mark to tell this kind from the blackheads.

This matter of distinguishing between the two is of decided importance, because, while the feeding habits are similar, there are vitally important differences that affect remedial measures. The yellowheads are, on the whole, stouter than the blackheads, and, as a rule, lighter in color. They are also less active and, especially when nearly full grown, do not so readily wriggle out of their nests.

The yellowheads grow fast, and are ready to pupate late in May or very early in June, a little before the blackheads appear. The second moths appear early in June, but are now bright orange red in color, whereas the first moths are slate gray. The second lot of eggs hatch toward the end of June, and the yellowhead worms are nearly half grown when the cranberries are in full bloom, early in July, when the second brood of blackheads has just started. They make even larger webs than the blackheads, and are even fonder of boring into the fruit. It is not uncommon to see half a dozen uprights and runners all tied together in one large web, in which leaves, even if not eaten, turn brown and die. By the middle of July or a little later the yellowheads are again full grown and change to pupæ. The worms spin a silken cell, in which the change takes place, and the pupa is dark brown or blackish, with a little knob-like protuberance on the head case. This peculiarity makes the species easily distinguishable from the same stage of the blackheads.

The third crop of moths appears late in July or early in August and are of the same orange-red color as the second. Eggs laid by these moths do not hatch until in August or even early in September, and the worms that come out of them grow slowly as compared with the earlier broods. Few of them spin up more than a single shoot and few of them eat into any but the smallest berries. They also tend to become reddish in color and even striped, so that at one time they were believed to form a distinct species, described as the red-striped cranberry worm. Not until after the picking, if anything be left to pick, do these worms become full grown. Very irregularly in late September and early October they come to maturity, and now the moths that come from them are, after a dust of orange wears off, of the slate-gray color seen in spring.

The application of insecticides on large bog areas where the plants cover the ground as densely as do the cranberry vines is a task no grower likes to contemplate; and provided he has control of a satisfactory amount of water there is no necessity for it. As against the yellowhead it will suffice if the water be held on the bogs until the middle of May, or perhaps a little later in cold seasons. By this time the huckleberry and heath plants have made a good growth and have tempted the hibernating moths to lay their eggs. Unless, therefore, the vines are uncovered at the edges or on knolls above water, the plants will be free from the first brood of worms. In the woods and on the upland plants the worms and even the moths are exposed to the attacks of birds and many predatory insects that never go upon the bogs; hence the adults of the first summer brood will not be nearly as plentiful as if they had bred on the vines. Only a few, comparatively, of the moths will fly upon the bogs, and even then do not usually get very far from the edges; so that the heavy, very injurious middle brood will be reduced to practically harmless numbers. The third brood, even if it does spread over a greater area, is not likely to prove troublesome, for reasons already stated. Hence, care and attention to the drawing of the water in spring will of itself suffice to keep this insect in check. If to this we add the destruction of the heath and huckleberry plants immediately surrounding the bogs, the nearby breeding places are further reduced and the bog is the more likely to remain free.

As against the blackhead late holding will not of itself suffice, because the eggs are already on the plants and will, under ordinary circumstances, hatch only under the same conditions that favor the start of vines themselves. But there is a little leeway in favor of the plants, and the eggs do hatch under water at a temperature not quite sufficient to start the vines. To hatch the eggs the proper temperature only is needed; to start the vines there must be also sun and air. If, therefore, a bog is tolerably level the water may be drawn from below until it just covers, and may be held there even after May 15, until the starting of the vines indicates that the danger point has been reached, and then it must be drawn to avoid killing the fruit buds. Runners or laterals not bearing fruit buds will stand a quarter or even a half an inch start under water without danger unless the water is drawn on a very warm day, and then there is danger of scalding. The further advanced the plants the greater that danger becomes; hence great care and good judgment must be exercised when this measure is adopted. Fruit-bearing uprights can not be safely permitted to make more than a mere start. On a sloping bog, where the water is deep at the gates and becomes shallow at the edges, the water may be gradually drawn from the bottom so as to leave the warmer surface water, and in this way practically all the eggs will come under the influence of the moist heat that favors their development.

Carefully carried out, this measure is often very effective; the warmth favors the development of the embryo within the egg, and when the worm hatches it drowns. Occasionally a specimen may bore into a leaf and so maintain itself twenty-four hours or more, but usually it stifles without getting even a bite. Sometimes badly infested bogs are completely freed by this method without apparent injury to the setting of fruit, yet at times the crop is reduced one-half by holding a little too late. In the latter case, however, the crop had been destroyed by the insect for several years in succession, and the owner was quite willing to sacrifice 50 per cent if thereby he got rid of the insect, as he did. This method should be employed only when reflowing is not possible.

When the supply of water is abundant above the bog area, so that a pond or reservoir may be formed, both the yellow and blackheads may be completely controlled by drawing the water early, waiting until all the eggs have hatched and some of the worms are nearly half grown, and then re-covering the bog with water for forty-eight hours. This method is so simple and so absolutely effective that the larger growers are adopting it almost universally, and few new bogs are laid out anywhere without considering the matter of reflowage and providing for as good a control of the water as possible. Under proper control the water may be drawn from the bogs when the best interests of the plant demand it without any regard to insect conditions. If worms appear in any number toward the end of May, the bogs are reflowed, and rarely is this necessary more than once in three years. Only when the bog area is small and the surroundings are very bad is annual reflowage needful. For a complete effect the vines should remain covered forty-eight hours, because it requires some time for the water to penetrate the spun-up leaves so as to kill the worms. Many, indeed, especially the half-grown blackheads, wriggle out, seeking to escape when the water reaches them, but those nearing maturity are less active, remaining at home until the water surrounds them and they simply can not get out. Covering the bogs should begin in the late afternoon and should be completed before next morning, if possible. On a rainy day it may begin at any time, the object being merely to prevent the sun from boiling the young shoots. So drawing off the water should also begin in the early afternoon, and the bog should be practically dry the morning after.

Incidentally this reflowing will rid the bog of numerous other pests and may make a material impression on the girdle worm where that is abundant.

The importance of a sufficient water supply has come to be so generally recognized among advanced growers that in New Jersey miles of ditches tap streams far away from the bogs, and in Massachusetts expensive pumping machinery has been installed to raise water in large quantities to high-bog areas.

It is sometimes possible to use the upper one of a series of bogs as a reservoir, holding a full head of water as late as it is safe to reflow the lower bogs of the series which have been drawn early. In one series of 100 acres, divided into 5 sections by cross dams, a fall of about 10 feet is utilized to reflow all save the uppermost section, and this practice is possible in almost every case where water is available.

Sometimes it happens that bogs can be neither winter flowed nor reflowed, and the application of insecticides becomes an absolute necessity. Only arsenics are to be relied upon for good results, although for a long time tobacco was and in some parts of Massachusetts is yet the main reliance. It follows from what has been said concerning the habits of the worms that when once they have spun up the tips and are feeding in their cases they are practically beyond the reach of our common insecticides, and that is particularly true of the first brood. If there is reason to believe from past experience, or because eggs have been found on the plants, that the early brood will be numerous, spraying must be done just as soon as the vines make a start or not later than the date when the first spun-up tip is seen. The object is to get the poison into position before the leaves are spun up, so that the worms may find their first meal poisoned. If spraying for the first brood is omitted, that for the second brood should be timed in the same way, and, because the worms now spin up a greater amount of vegetation, the chances of killing them off are greater.

All things considered, the best insecticides for use on cranberry bogs is arsenate of lead, either in the paste form as sold by certain makers of insecticides or made up by dissolving separately 4 ounces arsenate of soda and 7 ounces acetate of lead in water enough for that purpose, then combining the solutions in a tank to which 50 gallons of water may be added. If the paste arsenate is used, 1 pound in 40 gallons is better.

Any sort of machine or pump may be used and any nozzle that makes a reasonably fine spray. The point to be aimed at always is the terminal growth, because it is there that the insects feed. Nothing will be gained by driving the mixture into the body of the vines, especially if they are long and densely matted. The conditions on the bogs vary so much that every grower must determine his outfit according to his own needs. In some cases horses can be used on the bogs to draw a geared machine of large capacity; in others they are out of the question; and so the size of tank from which the spraying is done and the way in which it is mounted must vary according to circumstances.

It may under some conditions be more satisfactory to apply a dry insecticide, and for this purpose there are now several dust sprayers and powder guns on the market. By means of a fan blower a fine powder can be rapidly and evenly distributed over a large area, and this would naturally lodge just where it was needed. A good mixture for such application is 1 pound of fine Paris green to 10 pounds of dry hydrate or fresh air-slaked lime. The lime should be sifted, thoroughly mixed with the Paris green, and the combination applied while the vines are slightly moist.

The Cranberry Tip Worm.—This is a minute orange-red or yellowish grub about one-sixteenth of an inch in length, found in the growing shoots, whether uprights or runners. It is comparatively rare on Cape Cod and is not common on all the New Jersey bogs, though more plentiful there than anywhere in Massachusetts. It appears on the vines soon after they make a start, and the first indication of its presence is when the small leaves of the tip cease to unfold and become bunched into a compact, bulb-like mass. When this mass is opened, from one to five, and usually two or three, of the little grubs will be found at the very heart of the growing tip, feeding upon the juices and completely checking growths. If it is a runner that is attacked, it is destroyed; if a fruit-bearing upright, the flower buds come out below the infested tip and no harm is done to the crop. But the insects continue to appear on the bogs at intervals throughout the season, and the danger is that the late-tipped uprights will form no fruit buds for the next year.

The little grub is rather a helpless sort of a creature, without legs and even without distinct jaws; but it has on the underside of the body a little horny process or breast bone by means of which it scrapes the plant tissue until the cells break down and their contents may be absorbed. In about ten days it reaches full growth, envelops itself in a thin, white, silken cocoon, and two or three days thereafter changes to an adult—a minute, two-winged fly or midge whose wings when expanded measure less than an eighth of an inch from tip to tip. The male is quite uniformly yellowish-gray and inconspicuous, but the female has the abdomen deep red, the upper surface of the body gray, the sides yellowish, the head and eyes black. She also has a slender, extensile tip to the abdomen, by means of which the minute white eggs are laid in the very heart of the bud.

After the fly has emerged from one of the infested cranberry tips the leaves that were massed together turn red or brownish, die, and break off, leaving a stub above the fully developed leaves. If the tips are killed early in the season fruit buds may form at the axils of the leaves, or one or more little spurs may start lower down on the shoot, at the tips of which normal fruit buds may develop. On new bogs, with young, vigorous vines, the early broods cause no damage at all and the late broods very little. On old bogs, with long vines, the earlier broods do little harm, but the later broods materially injure the crop prospects for the year following by preventing the set of buds on the injured uprights.

Strictly speaking, no direct remedial measures are known. It is not known positively how the insect passes the winter; hence control can not be attempted at that season. The worm never comes within reach of our ordinary insecticides, and therefore direct attack is not possible. Since the loss of the tips attacked in spring does not injure the crop of that year, the effort must be to keep the vines in such vigor that they will set fruit buds on laterals and at leaf axils when the direct tip has been lost. How this vigorous growth is to be obtained the grower will be best able to determine.

This insect is not confined to the cranberry, and in fact breeds much more abundantly on loose strife and on some of the heaths. Therefore, where the species is troublesome, those plants should be kept down on the dams and other bog surroundings. Tip worms occur on both flowed and dry bogs, and reflowing does not reach them; but as they first occur on flowed bogs around the edges, the inference is that the winter is passed on the upland, on or in some one or more of the alternate food plants. This would make the destruction of such plants an effective measure.

*The Cranberry Spanworm.**—In some sections of Cape Cod certain span, inch or measuring worms occasionally become injuriously abundant, and the most destructive of these is the species above named. The parent moth is much larger than any of the other forms found on the bogs, the broad fore wings expanding 1½ inches or thereabouts. In general color it is pale ash gray, sprinkled with black, and both wings are crossed diagonally by black lines and shades. The lines have a tendency to become toothed or scalloped, and the wing margins themselves are also a little notched. The worms first appear on the bogs in June and become full grown by the end of that month or early in July. They are then rather more than an inch long; slender, smooth, livid gray caterpillars with a deeply indented head and a long, pointed anal plate. They have three pairs of short legs close behind the head and two pairs near the anal end. When they walk, they first stretch out at full length, take hold with the anterior legs, then bring the posterior pairs close to the others, the middle of the body forming a loop. This mode of progression gives them the common name "loopers" in addition to those already mentioned. At rest or when not feeding, the caterpillars hold fast by the anal legs only, and stretch out the remainder of the body at an angle, and so rigidly that they resemble leafless bits of vines. On a section of bog on which they have been feeding the observer may stand in the midst of thousands of them and see none until something starts them into motion; then it appears almost as though the entire bog was alive.

* See page 645, for illustration.

When full grown they bury themselves a short distance beneath the surface and change into rough, brown, rather stubby pupæ, from which the moths emerge a few days later. The second brood of caterpillars matures early in August, and pupation begins before August 9. Though worms will continue to be present in numbers until after the middle of the month, the moths appear at its end and in September.

There seems to be no regularity in the appearance of these insects. In some years they are not seen at all; in others they may be locally abundant, and only occasionally do they seem to occur everywhere in great armies. Usually they start from some point near the edge of the bog, spread out a little, and then move in an almost direct line ahead. Sometimes the beginning is nearer the center, and the eating may be in all directions from a given point where some groups of eggs were laid. It is the first brood which, as a rule, starts near the edges. The second brood starts from inside centers, and when these are numerous the boundaries of the individual broods become lost, and, the masses uniting, an army is formed which, as it advances, plays havoc with the crop. Not a green thing is left on the vines, and in a few days acres may change from green to brown; from a smiling promise of a full crop to the barrenness of desolation.

Being an open feeder upon the foliage, this span worm is susceptible to arsenical poisoning and unless the bogs can be rapidly reflowed and as rapidly laid dry, spraying or dusting are the only alternatives. Where the worms are noticed when they first start, spraying the foliage just ahead of them may answer all purposes, and indeed this poisoning of their line of advance should always be done before treating the parts already infested. Either Paris green at the rate of 1 pound in about 160 gallons of water, may be used, or the arsenate of lead or a dry powder may be applied, as for the blackheads and yellowheads.

The Cranberry Girdler.—This species more commonly known as the girdle worm, is found abundantly in all the cranberry districts, but it is seriously injurious in Massachusetts only. The larvæ, which are slender, grayish caterpillars, with shining, light chestnut-brown heads, and yellowish thoracic shields, pass the winter in a torpid condition within a silken tube or cocoon, which resists the entrance of water. In New Jersey the adults are found in May, on and around the edges of the bogs; in Massachusetts they do not fly until July, and there is evidence that the worms do some feeding in spring before they actually change to the pupal stage. This change to the pupa takes place in the tube or cocoon made in the previous fall, and on Cape Cod at the latter part of May or in early June. The adult is a pretty little creature, with fore wings expanding about three-fifths of an inch, and is one of the long-snouted moths, the palpi or mouth feelers projecting well beyond the head. The fore wings are rather narrow, very pale straw-yellow in color, with smoky lines in the interspaces between the veins and narrow silvery cross bands at the outer part, near the margin. The hind wings are much broader and of a uniform silvery gray. When the moth is at rest the wings are so closely wrapped around the body that it looks like a narrow whitish cylinder about three-quarters of an inch in length.

The young worm is very active and strong, and at once begins the construction of the silken tube reenforced by bits of vegetation, in which it lives. It works about the running portion of the plants extending along the surface of the sand in the stratum of fallen leaves which always cover an old cranberry bog and from which the delicate clusters of new rootlets take their rise. Everywhere over an infested area, but especially along its borders, these worms can be found in filmy silken galleries following the prostrate stems of runners, into the surface of which they eat their way, destroying the vital part of the plant and, especially next to the base of the runners, deeply girdling the stem. They grow rather slowly, and not until November do they make their course cocoon of mingled sand and silk that serves as winter quarters.

It seems probable that in Massachusetts there is only one brood of the moths which is active in July. In New Jersey, on the other hand, the moths have been found in every month from about May 21 to the middle of September. There must be, therefore, at least two broods, which develop very irregularly. With this difference in the life cycle in the two States there is an evident divergence in food habits, for there is no such destruction of large tracts in New Jersey as is found in Massachusetts. That the insect is not specifically a cranberry feeder is proved not only by the fact that it occurs not uncommonly many miles away from any cranberry plantation, but also by the direct evidence of an investigator who actually bred it on the common grasses and found further that the worms would eat freely of sheep sorrel. The cranberry feeding habit seems to be, therefore, a somewhat local characteristic and this gives hope that by persistent work this bog variety may be in large part stamped out.

An infested bog is rarely affected over its entire extent. Small areas varying from a few feet in diameter to half an acre or more are found here and there, and sometimes a little patch only a foot or two across will remain for two or three years in succession without becoming enlarged, but rather it will become closed up by runners from the adjacent healthy vines. Larger areas tend to become larger, new vines dying from the edges each year. A restart over areas so killed out is very slow, yet it does usually occur after the second year; but the growth is apt to be irregular and requires some time before it comes again into bearing condition.

It is quite obvious that insecticides are not available here, because of the concealed feeding habit, and that resort must be had to more direct methods. The suggestion is therefore made that, immediately after the fruit is off, infested bogs be flowed and be kept covered for at least a week, and better two weeks. This should be effective against these worms and harmless to the vines. While the ripening fruit is on, any water covering kept on over twenty-four hours would be apt to do material injury.

An additional suggestion is that the actually infested area be completely burned off as soon as its extent can be determined. The vines already attacked are doomed at best, and if in destroying them the insect can be also killed the loss will be balanced by a greater benefit. For this burning a gasoline torch may be employed, and the heat thus applied directly to the point where it will be most effective. The use of the torch will also prevent setting a fire that might injure other portions of the bog, since it can be used when the vines are so wet that they will not burn under ordinary conditions. The burned-over area can be immediately reset and the actual amount of injury limited to a minimum.

If burning is resorted to, it should be done as early in the season as possible and should be extended far enough to cover the entire infested portion of the bog.

The Cranberry Fruit Worm.—This is another species that is much more injurious in Massachusetts than in New Jersey, though it is by means unknown in the latter State, and in some seasons and localities does considerable damage. As a rule, bogs that can not be reflowed and high and sandy bogs suffer more.

The adult moth appears on bogs in ordinary seasons about the middle of July, when the berries are setting or have already set. It is probable that the moths remain on the bogs for a period of at least a month, as indicated by the very unequal development of the worms that are found in the berries in early September.

The moth, with wings expanded, measures about three-fourths of an inch and is of a glistening ash-gray, mottled with white and blackish. The forewings are narrower than the hind wings, which are more smoky gray in color and have no markings. It is a shy species, not easily started during the day, and flies with a darting motion for quite long distances. It is not generally recognized, therefore, even by growers who annually lose heavily by it. When at rest the wings are folded close to the body, and on a cranberry stem, where it usually rests head down, it is not readily seen even by an experienced eye.

The eggs are laid on the young berry, preferably in the calyx, just beneath one of the lobes, but they may be on any part of the berry and possibly on the leaves as well. They are very slightly convex, almost flat, round in outline, pale yellowish in color, and so soft that they adapt themselves readily to any inequalities of surface. The worms emerge in about five days, and for a day or two feed on the outer side of the berry. Then each worm enters a berry, eats out the seed chamber, and migrates to another. The vacated berry turns red, shrivels up, and eventually drops. The worm, on entering its new home, carefully closes the opening behind it with a web of fine silk, so dense that it is sometimes difficult to see where the hole was made. In this second berry it becomes half grown, then works out through a large jagged opening and gets into a third berry, closing the point of entry as carefully as before. By this time the season is pretty well advanced, the fruit is of good size, and, soon after the worm starts feeding, the newly infested berry begins to turn red. To the ordinary observer the fruit is ripening nicely, if early; but the grower knows better and realizes that every such specimen is lost to him. Not unusually the worm completes its growth in this berry, but if it does not it eats into a fourth. This time it makes no attempt to seal up its point of entry; very often it spins together a little cluster of berries, eating from one into the other and ruining all of them. Full growth comes, as a rule, in late August or early September, just before picking time; then the caterpillar leaves the berry and in the sand at the base of the plants spins a rather close silken cocoon, in which it passes the winter. But quite frequently the worms do not get their full growth at picking time, and emerge from the berries after they are harvested and in the cranberry house. These delayed forms make their way to any crevice or other shelter that they can find and there spin up for the winter rest.

At this time the worm is rather more than half an inch in length, of a bright-green color, with a variably marked reddish tinge on the back. The head is a little narrower than the first body segment and is of a more yellowish color, except the mouth, which is brown. The body segments are transversely wrinkled, clothed with a few sparse, rather long hairs. As a whole this is decidedly the stoutest of those occurring on the bog as injurious species.

The full-grown caterpillars winter in their silken cocoons, which they make by first rolling in the sand, gluing the particles together with saliva, and then spinning their web inside of the rough casing so formed. Pupation begins toward the middle of April with specimens that have been dry during the winter, but probably not much before the end of May or early June on the bogs. The pupa is brown, rather chunky, and of the same general form as in the species already described.

Winter flowage is not fatal to these insects, and covering the bogs with water at any time after the winter cocoon has been formed would probably be ineffective. Nevertheless, as already indicated, water-covered bogs are less troubled, and it is probable that the earlier the water is put on in the fall the more effective this practice will be.

Indications are that if a bog can be safely submerged for forty-eight hours between August 10 and 15, just before the worms reach their full growth, the great majority will be killed off. Sound berries covered for that length of time will not come to harm if the water can be put on and drawn off rapidly enough to avoid scalding. Fruits not quite so far advanced may be covered for even a long time without injury, but there is always a risk which the grower should fully consider before he acts. The vines should be completely covered before the sun beats upon them high enough to warm the water, the covering should be sufficiently deep to prevent a scalding effect, and when the water is drawn sunrise should find at least every berry above the water level, that the drying off may be gradual. A cool day would almost insure safety to the berries, an intensely hot one might cause injury, and the nearer maturity the fruit the greater the danger. Nevertheless, despite the danger, reflowage is advisable, provided it can be done within the time limit given.

If reflowage be not practiced, pick the crop as soon as it is at all practicable, so as to get as many wormy berries off the bog as may be. The worms will emerge in the cranberry house and form their cocoons in cracks and crevices or among rubbish. Give them plenty of shelter in the way of loosely piled slats, boards, or other cover, placed wherever conveniently possible, and any time during the winter clean up thoroughly, so as to reach the hibernating worms. Field mice will eat these worms. Also a liberal use of gasoline in such places under the usual precautions against fire would reach every one of them.

Insecticides are possible only during the two or three days in which the young worm feeds on the outside of the berry, and the only material that offers any chance of good results is arsenate of lead. If when the worm starts feeding it finds a poisonous meal prepared its career will be ended at once. It must be remembered that any application to be at all effective must be on the berries by July 10 and must be maintained there at least a month to get most of the hatching worms. Arsenate of lead is the most lasting of all the arsenical sprays, but new berries are being added constantly as new fruit sets, and at that season growth is rapid, so that a week will add a large amount of new, uncovered surface. One spraying per week for three, or preferably four, weeks offers a fair chance of success by killing off the berry worms before they get into the berry.

On bogs that can not be flowed the arsenate of lead, aided by early picking, will probably reduce the amount of injury materially; but on such bogs the development of the moths may occur earlier and the grower must rely more upon the stage of growth, or, better, the appearance of the moths themselves on the bog, than upon any absolute dates.

The Cranberry Katydid.—One of the most destructive insects on the New Jersey bogs is a species of katydid, though its injuries are, as a rule, charged to grasshoppers in general. On Long Island the damage is less marked, and in Massachusetts the insect is practically unknown.

The injury is chiefly caused by the feeding habits of the adult of one species which chews into the berries when half to full grown, rejects the pulp, and eats the seeds. Other species have similar habits, but occur more rarely. The injured berries wilt, shrivel, and die; but when they have just been left by the katydids, the common, shorthorned grasshoppers feed on the exposed pulp and, being detected in this, are quite generally charged with having caused the entire trouble. One katydid may eat out several berries at one sitting, and when the insects are at all abundant the per-

Front Edge of Sheet Tent and Tops of Derricks Ready to be Pulled Over Tree. Dept. of Agr.

(See page 388.)

Sheet Tent Ready for Introduction of Chemicals. D...

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centage of fruit destroyed is very large; on some bogs the amount reaches almost or quite one-half the entire crop.

The katydids when mature are green, grasshopper-like insects, with very long antennæ, or feelers, and long slender hind legs. The fore wings are also green and are narrow, a little thickened, not used in flight. The hind wings are decidedly longer, much broader, very much thinner, almost transparent, and longitudinally folded under the fore wings when at rest. Fully expanded, these wings measure from 2 to 2½ inches between tips, and the body is about 1¼ inches in length. In the male there is a little triangular area at the base of the fore wings where they overlap, and where a few ridge-like veins form a musical instrument by means of which they produce their chirping song or call. In the female this structure is absent, but we find at the end of the abdomen a broad scimitar or sickle-shaped ovipositor, by means of which the eggs are laid.

The young wingless katydids are found around and at the edges of the bogs about the middle of June, but do not mature until early in the following August. Not until they reach the pupal stage, after the middle of July, does the berry-feeding habit become developed, but from that time until the fruit is picked their fondness for this kind of food increases, and the insects themselves increase in number on the bogs. The first eggs are laid about the middle of September and the laying continues until about the same period in October. By that time the insects have disappeared and nothing more is seen of them until June of the following year. The eggs are laid chiefly in two kinds of grasses, locally known as deer grass and double-seeded millet.

Occasionally eggs are laid on other grasses or plants, but never on cranberry leaves. They are laid chiefly at night on the drier parts of the bog, in the edges of the leaf between the upper and the under surface, to the number of from one to five in one blade; the single number is much the more usual. When deposited the egg is very flat, almost three-sixteenths of an inch long, less than half as wide, slightly kidney shaped and of a very light yellowish brown color. The disk of the egg is closely and roughly marked or netted without definite pattern.

The character of the remedy to be adopted follows from the egg-laying habits of the species. Allow none of the host grasses to maintain themselves on the bogs and burn over the dams during the winter while the bogs are flowed. From the fact that the very young katydids are never found on flowed bogs except at the edges joining the upland or at the base of the dams, it may be fairly inferred that the eggs do not survive the winter when kept completely submerged, so that destruction of the grasses above the water line might answer. It would be safer, however, to have the grasses out; they have no place on the bogs anyway.

For burning the grasses and other host plants on the dams some one of the gasoline torches now on the market may be used. They give a very intense heat and lick up leaves and plants with extreme rapidity. As they can be used against the wind or while the plants are somewhat damp there is practically no danger that the fire will get away, and when the ground is frozen, the covering of leaves and stalks is burned so rapidly that no heat gets to the roots. Growers consider it desirable to keep a cover of vegetation on the dams to strengthen or prevent them from washing, and this method will destroy the egg-bearing vegetation without also destroying the plants themselves.

The Ideal Cranberry Bog.—So much has been said of bog conditions, and bog conditions so greatly influence the abundance of injurious species of insects, that it may not be out of place to describe briefly what a bog should be to make insect control easy and certain.

(1) The bog should be as nearly level as it can be made, so as to require the least possible amount of water to flow it. A bog that can be completely covered by a 12-inch head is better than one that requires 24, and when the difference in level of an area is 5 or 6 feet or more it is better to make two bogs out of it, that the lower may be reflowed from the upper and less than half the amount of water be required.

(2) Make no one bog so large that more than thirty-six hours are required to cover completely, and no more than twenty-four hours are required to draw the ditch level.

(3) Build a reservoir or reserve a flooded area above the level of the highest bog of a series sufficient to hold water enough to flow at least the highest bog completely. The importance of this requirement is so fully appreciated that miles of ditches have been dug in New Jersey to tap streams at a higher level, and many acres of swamp area have been created by raising contour lines to deepen natural basins. In Massachusetts powerful pumps have been installed to pour water directly upon the bog or into a reservoir above it.

(4) Adjust bog levels so that the upper one of the series can be completely emptied into the one below, and yet have the gates and outlets so adjusted that any one bog may be completely emptied without interfering with either those above or those below. It happens not infrequently that one bog needs cleaning or other attention while others do not.

(5) There should be a broad, deep, marginal ditch between the dam and the bog or between the bog and upland, and this ditch should be always clean and at least partly full of water. Many kinds of insects can be altogether kept from the bogs in this way, while grasshoppers and other insects are delayed until they can fly. Then they are feeding on other things, and they do not often change the food habits of their early life.

(6) The dams and the edges of the uplands should be kept as free as possible from vegetation that harbors cranberry-feeding species. Cranberry vines should not be tolerated for an instant. Huckleberry bushes are almost as bad, and these should be cleared back for some distance where bog and upland join without an inter-

vening dam. Other heath plants are also undesirable and should not be allowed too near the bogs nor on the dams.

(7) It follows from what has been said that the bog itself should be kept as free as possible from all plants other than vines, certain grasses being especially objectionable because they are used by long-horned grasshoppers as places to lay their eggs.

Bogs so arranged could be kept completely safe at all time, and once properly laid out would require little outlay to keep them so. The question whether bogs should be kept wet or dry, whether there should be many or few ditches, and whether these should be deep or shallow need not be here considered at all. The dates of flowage and reflowage and other points of measurement by means of which control may be made effective have been already touched upon.

The important advantages are that neither insecticides nor spraying machinery would ever be required, and the insect problem would be reduced to the simplest possible terms.—(Farmers' Bul. 178 U. S. D. A.)

SCALE INSECTS AND MITES ON CITRUS TREES.

THE ARMORED SCALES.

The majority of the important scale-insect enemies of the orange belong to the group known as armored scales because the insects begin to excrete as soon as they thrust their beaks into the tissues of the plant a waxy covering which protects the growing insect and forms a definite scale-like shield entirely independent of the insect itself. This group includes the long scale, purple scale, the red scale of California and the red scale of Florida (an entirely distinct insect), the oleander scale, the chaff scale, and other less important species.

In general habits these armored scales are very similar. The eggs, which are developed in enormous numbers, may be extruded under the covering scale of the mother insect and undergo a longer or shorter period of incubation before hatching, or the young may be partly or fully developed within the body of the mother and emerge as active insects, or more properly shake off the egg envelope at the moment of birth, so that certain species appear to yield living young. The young of these different species of armored-scale insects very closely resemble each other, and can not be distinguished without careful microscopical study. While very minute, the young are yet visible to the naked eye, and during the breeding season may be seen, by sharp inspection, running about on the leaves, twigs, and fruit. In color they are usually light lemon-yellow. They have six well-developed legs, also antennæ and eyes, and are highly organized in comparison with the degraded condition soon to be assumed. After finding a suitable situation, often within a few minutes from the time of their emergence, though sometimes not for an hour or two, they settle down, thrust their long slender hair-like beaks into the plant, and immediately begin growth, the first evidence of which is the secretion of waxy filaments from the upper surface of the body, which mat down and form the beginning of the scale covering. This waxy secretion continues during the life of the insect, the covering scale being enlarged as the insect increases in size. The females undergo two molts, and the skins thrown off in these molts form a definite part of the scale, being cemented to it closely with the wax. The female insect, after the second molt, soon reaches full size, and when fertilized by the male begins to develop her numerous progeny.

The preliminary stages of the male scale exactly correspond with those of the female. After the first molt, however, the male assumes a slightly different appearance, being more elongate than the female at this stage. With the second molt the male diverges entirely from the female; the old skin is thrust out from beneath the covering scale, and does not become a part of it, as with the female, so that in the case of the male insect the first-shed skin only is associated with the scale, which never becomes more than one-half the size of that of the female. With this second molt the male insect transforms to a preliminary pupal stage, in which the antennæ, legs, and wings are partially developed. A third molt occurs with the male insect, resulting in the final pupal stage, which exhibits more fully formed legs and wings than the preceding stage and also the so-called terminal style. A fourth and last molt of the male produces the perfect insect, which escapes from beneath the covering scale and can fly about.

The periods between the moltings vary with different species and with weather conditions. Most of the species, however, reach full growth in from four to six weeks in summer; development is slower in winter.

The female insect, having once thrust her beak into the tissues of the plant as a larva and begun the secretion of a covering scale, never moves from her position; and, in fact, if she be removed by force is never again able to penetrate the bark with her sucking beak, and soon perishes. The opportunity for the local spread of these insects is, therefore, limited absolutely to the larval stage, as in this respect they differ from the Lecaniums and mealy bugs, which have the power to move about until nearly the end of their growing period.

The number of eggs from a single female varies somewhat with the species, but may be from 100 to 500, the number being less in unfavorable seasons. The progeny from a single female in a year, if they should all survive, would represent almost inconceivable numbers, running into the billions. It is not to be wondered at, therefore, that plants become thoroughly infested with these insects in a very short time, especially in climates where the breeding is but little checked by the winter season.

The waxy covering makes it necessary to use rather strong washes to penetrate the scale. The difficulty increases when the old scale protects a mass of eggs, as is usually the case with the species of Mytilaspis, represented by the long and purple scales; and it is not always possible with the best washes to kill all the eggs of these species, hence the necessity of spraying repeatedly to destroy the young as they emerge. Remedial operations should be instituted as far as possible when the greatest percentage of the scales are in a young or partly mature condition.

The Long Scale.—The long scale is supposed to have originated in China, but in common with most of the other species discussed has now a world-wide distribution, being represented in practically every important citrus region. It made its appearance in Florida about 1838, and soon became a very serious pest in that State and elsewhere in the Gulf region. At its first appearance it was vastly more destructive than later on, parasitic and natural enemies having in later years kept it decidedly in check. At present it is everywhere distributed throughout Florida and Louisiana in the orange and lemon groves, and also on wild orange. Strangely enough, it was a long while getting into California. About 1889 or 1890, however, in company with the purple scale and rust mite, it was carried into California on a lot of stock from Florida, but it has not developed as a very serious pest in the Pacific coast region.

This insect is characterized by its very elongate form; in other respects it closely resembles the long scale, and also the common oyster-shell scale of the apple and other deciduous fruits. In color it is a rather rich reddish, often obscured by extraneous matter taken from the surface of the leaves or bark. It apparently requires a great deal of moisture to thrive well, and hence is apt to be abundant on oranges or other plants grown in conservatories, and this also accounts, doubtless, for its greater multiplication and injury in Florida than on the Pacific coast. Breeding continues practically throughout the year. According to Hubbard, there are three periods in Florida when the young are especially abundant, marking in a rough way the appearance of the main broods, namely, in March and April, in June and July, and in September and October; the fourth, irregular brood, occurring in January or February.

The treatment for this scale is the use of the oily washes and fumigating with hydrocyanic-acid gas. It is much more easily controlled than the purple scale.

The Purple Scale.—The original home of the purple scale is unknown, but it now occurs practically wherever the orange or lemon is grown. It was probably introduced into this country at an early date. It is frequently associated with the long scale, and is one of the most troublesome scale insects affecting the orange and lemon, because it is very difficult to get an application on the trees strong enough to kill all of its eggs with one treatment. For many years the purple scale was limited in this country to Florida and the Gulf region, but some years since it was carried on Florida stock into southern California, where, fortunately, it has not yet become widely distributed. In general color it is a brownish purple, and in shape duplicates the oyster-shell scale of the apple. The life history and habits are the same as those of the long scale. The purple scale is not limited to citrus fruits, but occurs also on many other plants.

Neither the gas treatment nor any of the washes is a certain remedy for this scale, except in the immature stages. Occasionally a very strong treatment will kill the eggs, but it is usually necessary to repeat the application once or twice at intervals of two or three weeks to effect anything like extermination.

The Red Scale of Florida.—This is another scale insect of world-wide distribution. As an orange scale it is not a very serious pest on trees grown out of doors, but on trees grown in conservatories or under glass it is very apt to thickly infest the leaves and fruit. It has a very wide range of food plants and is one of the commonest of scale insects. This and the following species differ from the Mytilaspis scales in being nearly circular in general outline, with the molted skins in the center of the scale instead of at the small end. The color of this scale is a rich reddish brown, almost black. The central portion, however, is much lighter, giving the appearance of a dark ring with a light center. The number of generations can not be accurately given, breeding going on throughout the year, but undoubtedly in greenhouses and tropical regions six or seven generations are not unusual, and in subtropical regions five generations may be safely counted. It seems never to have attracted any attention as an enemy in the orange and lemon groves of California, the dry climate evidently not suiting it. The moist climate of Florida and the Gulf region seems more favorable to it.

The Red Scale of California.—This species is entirely distinct from the red scale of Florida. Its name comes not from the covering scale, as with the Florida species, but from the fact that the body of the mature female turns a reddish brown and shows through the thin transparent waxy scale. This insect, although for years very common and destructive in the groves of southern California, and enjoying also a cosmopolitan distribution, has, curiously enough, never appeared in a destructive way elsewhere in this country. Its origin is a matter of some uncertainty. It is now widely distributed, and has undoubtedly been a scale pest in oriental countries for centuries. It is not limited to citrus plants, but may occur on almost any plant growing in tropical or subtropical regions. It is the most destructive and injurious of all the scale insects affecting the orange in California, being especially troublesome in the districts about Los Angeles. So far no effective parasites or predaceous insects have been found to combat it. It is controlled by the oily washes, and also by the gas treatment. The young are born free, or, in other words, the insect is semi-oviparous, and therefore any wash which will kill the old scale will destroy the young also.

This insect has, in California, a rather well-marked variety, known as the yellow scale. This variety does not differ in any structural feature from the red scale, but the mature insect remains yellowish in color. This variety is attacked by quite a number of parasitic flies, which keep it more or less in check, so that it is not, as a rule, so abundant as the red variety.

The Oleander Scale.—This species is not distinctively an orange pest. It occurs on a great variety of plants and has a world-wide distribution. It occasionally occurs on the lemon and orange, especially in California, not apparently being so likely to attack this plant in Florida. It is a very delicate scale, with a very thin waxy covering, and yields readily to treatment. It frequently occurs on the oleander, and is commonly known as the oleander scale. The male scales are white and very greatly exceed the females in abundance. The female scales are light buff in color with a faint purple tinge, rather than white, are two or three times the size of the male scales, and rather larger also than the scales of the species already described. The fruit of the lemon and orange is often invaded by the females of this species.

The Chaff Scale.—With this scale insect the molted skins are at one end of the scale, as in the case of Mytilaspis, and the scale is oval or nearly circular, as in the case of Asipdiotus. It is very apt to be clustered thickly, often overlapping on leaves or twigs and fruit, giving the surface a rough appearance, as though covered with loose chaff. In color the female scale is light straw-yellow, the female insect showing through, usually with a greenish tinge. The number of generations and life history correspond very closely with the species already described. As a rule, the chaff scale by preference remains on the trunk and branches, covering these portions of the plant densely before going on the leaves and fruit. This fact renders it somewhat less noticeable than the other species, and its presence may, for a time, be overlooked.

The chaff scale has been destructive, so far, only in Florida and the Gulf region, having apparently been introduced from the Bermuda Islands or some of the West Indies. It is closely allied to certain scale insects occurring in the Old World, and probably came to this country from Europe or Asia. It yields to the same treatments which are advised for the other armored scales.

The Orange Chionaspis.—This species occurs in the orange groves of the Eastern United States, and is also especially troublesome in Louisiana. Professor Morgan reports that its presence on the trees causes a bursting of the bark and very ugly wounds, followed in very many cases by the rotting of the trunks of the older trees. The orange Chionaspis is found also in several of the West Indian islands, Mexico, and in most foreign countries where citrus fruits are grown. The male scales are striking objects on account of their white color, and the females are readily distinguished from the other armored scales of similar general shape by the distinctly ridged appearance of the waxy portion. The orange Chionaspis is readily controlled by the same treatments advised on a previous page for the other armored scales.

The Unarmored Scales.—The species to be considered in this group include three Lecaniums, the mealy bug, two wax scales, and the fluted scale. Strictly speaking, the Lecaniums are the only ones which secrete no covering. The mealy bug secretes a waxy or mealy powder, which covers its body, and a similar secretion in less amount is made by the fluted scale. Both of the latter species secrete very abundant quantities of wax for the protection of their eggs. The wax scales cover themselves with copious waxy secretion, which, however, attaches firmly to the body, and can not be considered as a separate covering in the sense of the scale of the armored species. The development of the different species in this group is very similar, in that they all retain the power of locomotion until nearly the end of their lives, and do not suffer the loss of limbs and the marked retrograde development already described in the case of the armored scales. They excrete liberally the honeydew, which is followed by the smut fungus. In this group are included some of the worst scale pests of the orange and lemon, notably the black scale, the fluted scale, and the mealy bug. Not being so firmly attached nor so protected by a covering shell or scale, they are as a rule more easily destroyed by fumigation or sprays, and they fall a more ready prey to attacks of predaceous and parasitic insects. All of the species are egg-laying. Their Lecaniums and wax scales deposit their eggs in cavities under their bodies, formed by the contraction of the female insects, so that ultimately the mothers become mere shells over vast numbers of eggs and hatching young. The mealy bugs and fluted scale excrete a quantity of cottony fibers, which are stocked with eggs. After a certain amount of incubation, the young hatch and escape from beneath the old parent scales or burrow out of their cottony nests. In transformations and general life history, except in the points noted, these scale insects closely duplicate the habits of the armored scales.

The Black Scale.—This scale insect is notably an olive pest, but it also attacks citrus fruits, and is quite as destructive to the latter as to the olive. It is an insect of world-wide distribution, having been an important enemy of the olive and citrus fruits in the Old World as far back as we have any records. It also affects a great variety of other fruits and plants. It occurs more or less in greenhouses, and has undoubtedly been transported to various parts of the world upon greenhouse plants as well as upon the various subtropical fruits. In the United States it is especially destructive only on the Pacific coast, and while it occurs generally in Florida it has never there assumed any great importance as an enemy of the orange or lemon. It not only saps the vitality of the plants by the extraction of their juices, but also abundantly secretes honeydew, which results in a badly attacked plant becoming thoroughly coated and blackened with the sooty fungus.

The adult insect is dark brown, nearly black, in color. Its characteristic features are the one longitudinal and the two transverse ridges. Very often the portion of the longitudinal ridge between the two transverse ridges is more prominent than elsewhere, giving a resemblance in these ridges to a capital letter H. The general surface of the body of this scale insect is shagreened or roughened, which will distinguish it readily, under a hand lens, from the allied species, even before the ridges have become prominent. Very fortunately for the citrus grower, the development of this insect is slow, and it has but one brood annually. The young, however, appear over a very wide interval of time, and this gives the appearance of more than one brood.

On reaching full growth, early in the summer, the female insect deposits her eggs beneath her already much-hardened parchment-like skin, the lower surface of the body gradually contracting until there is nothing left but the shell, covering a mass of hundreds of eggs. The eggs will hatch in a comparatively short time, but, as the females come to maturity at different dates, the young from this species are constantly appearing and spreading over the infested plants between June and the end of October. The growth, however, is very slow, and even those earliest hatched do not reach maturity until late in autumn, the latest maturing in June and July of the following year.

While retaining the power of movement practically throughout its development, this scale insect is very little apt to change its position after it is once settled, or, at least, after it is half grown. There is a general migration from leaf to twig, but the scale often develops on the leaf if the latter remains vigorous and supplies it sufficient nourishment. The remedial measures for the black scale are spraying with the oily emulsions and the gas treatment.

The Soft Scale.—This scale insect also known as the turtle-back scale or brown scale, is closely related to the black scale, but is a much softer and more delicate insect. It changes in color with age from a transparent yellow in the young to deepening shades of brown in the adult. The adult scale has a length of 3 or 4 millimeters, is turtle-shaped, and very much swollen, the body of the mother in the last stages becoming a mere cap filled with young. In the early stages the insect is thin and flat and semitransparent, so that it is scarcely noticeable on the surface of the leaf or twig. It is very commonly found on various greenhouse plants, and has been carried to all parts of the world on such material. In climates suitable for the growth of the orange and lemon it occasionally gains a foothold on outdoor plants. It has a gregarious habit, and commonly lives in colonies, frequently covering the young limbs and the midribs of the leaves. These colonies are usually not of long duration, being soon attacked and exterminated by parasitic and predaceous enemies, the soft texture of the insect not furnishing much, if any, protection. The transformation and habits are very similar to those of the black scale. It, however, is much more rapid in growth, and, where the climate is favorable, goes through a continuous series of generations, or broods, throughout the season. It readily yields to oily washes or to the gas treatment.

The Hemispherical Scale.—This scale is also distinctively a greenhouse pest, and it can hardly be considered as especially injurious to citrus trees in orchards. It occurs all over the world, and occasionally will multiply to a slight extent on orchard trees. The individuals are about the same size as those of the last two species. In color it ranges from light brown in the young to dark brown, changing to reddish in the old scale. The adult scale is hemispherical in shape, perfectly smooth and shiny, and this, with its color, readily distinguishes it from the other two species. The remedies are those used against the black scale.

The Florida Wax Scale.—This very curious and striking scale insect secretes a white waxy covering, arranged in a very regular geometrical pattern. It was long known from Florida, where it is undoubtedly native, its principal food plant being the gall berry. It has now been carried, however, to other parts of the world, notably some of the adjacent West Indian islands, and also to the Old World. It was imported into California on stock from Florida in 1889, and possibly earlier, but has never gained any foothold on the Pacific coast. This insect often occurs on citrus plants, though rarely in sufficient numbers to be of very great importance. The white color and striking appearance of these scales cause them often to be noted, and very natural fears of damage are excited, but as a rule the natural enemies and other causes result in very few of the young reaching the adult stage. This, as shown by Mr. Hubbard, not only follows the action of parasites, but also is due to the fact that the scale lice as they become old and gravid can not maintain their hold on the smooth surface of the lemon or orange leaf and fall to the ground and perish. The citrus plants, therefore, are not especially adapted to this insect and very rarely suffer long or seriously from it.

The Florida wax scale is three-brooded, developments not being very rapid and extending over three or four months. The waxy secretions give an appearance to the young insect of an oval stellate object, the waxy prominences coalescing and disappearing with age.

The Barnacle Scale.—This insect, which is closely allied to the last, has been found in two or three localities in Florida, notably at Jacksonville and in Volusia County, on orange and quince, and also on a species of Eupatorium. It is frequently associated on citrus plants with the Florida wax scale. It has since been found on the same and other food plants on some of the West Indian islands and in Louisiana and California. The barnacle scale is much larger than the Florida wax scale, having an average length of 5 millimeters and a width of 4 millimeters. The waxy covering is a dirty white, mottled with several shades of grayish or light brown, and the division of the waxy excretion into plates is distinct, even to a late age. The development of the insect and secretion of the waxy scale covering is very similar to that of the last species described. The barnacle scale is of very little economic importance, and is mentioned merely because its presence might arouse suspicions of probable injury.

The Fluted Scale.—Of all the scale insects attacking citrus plants, this species is perhaps the most notable, not so much from damage now occasioned by it as from the problems of control which it has brought to the front and the international character of the work which it has occasioned.

The facts indicate that Australia is undoubtedly its original home, from whence it was introduced on Australian plants into New Zealand, Cape Town, South Africa, and California at about the same time. The evidence points to its introduction into California about the year 1868 on *Acacia latifolia*. It is a very hardy insect, will live for some time without food, and thrives on a great number of food plants. In California it spread rather rapidly, and by 1886 had become the most destructive of orange scale pests. The damage occasioned by it was of such a serious character as to threaten the entire citrus industry of the Pacific coast. The nature and habits of this insect made it almost impervious to any insecticide washes, and the orange growers of California were rapidly losing heart.

In 1889, however, through the agency of Mr. Albert Koebele, an assistant of this office, the natural ladybird enemy of the fluted scale was discovered in Australia and imported into California. This ladybird, *Novius* (*Vedalia*) *cardinalis,* multiplied prodigiously and in a very short time practically exterminated the fluted scale, saved the State of California annual damage amounting to hundreds of thousands of dollars, and removed this scale insect from the roll of dreaded injurious species.

The beneficial results derived from this ladybird have not been confined to California. Through the agency of this Department and in co-operation with the California State authorities, this ladybird has been sent to South Africa, Egypt, Portugal, and Italy, and in each of these countries its introduction has been followed by similar beneficial results in the control of the fluted scale.

While the fluted scale, at the time or soon after its injurious record in California, gained access to several foreign countries, very fortunately Florida and the Gulf districts remained long free from it.

The first and presumably only introduction of this insect into Florida was an intentional one, though not malicious, and illustrates the risk run in importations of beneficial insects undertaken by persons unfamiliar with the subject. A nurseryman of Hillsboro County, Fla., hoping to duplicate against the common Florida scale insects the wonderful work of the imported Australian ladybird against the fluted scale in California, and, ignorant of the fact that the ladybird in question did not feed on any of the armored scales which he especially wished to have controlled by it, got one of the county horticultural commissioners of California to ship him a lot of these ladybirds, together with some of the fluted scale as food. The whole lot was liberated on his premises and resulted, naturally enough, in stocking some of his trees very thoroughly with the fluted scale. The infestation coming to his attention, he sent, in June, 1894, specimens to the Division of Entomology and they were promptly determined as the dreaded California scale pest. Fortunately, the nurseryman in question realized the enormity of his offense and took, at Dr. Howard's earnest suggestion, immediate and active measures to exterminate the fluted scale on his premises, ultimately taking out and burning the trees.

It was hoped that extermination had been effected, but four years later (1898) the fluted scale was again received from the same district. In view of its quite general spread, as reported, in the immediate region, it seemed improbable that it could be easily exterminated, and the introduction of the Australian ladybird was urgently advised. During the spring and summer of 1899 the ladybird in question was successfully colonized in Florida by Mr. Gossard, with the assistance of Mr. Craw.

The fluted scale in Florida evidently does not multiply as rapidly as it does in California. Furthermore, as shown by Mr. Gossard, it is attacked by a fungous disease which appears suddenly in July and results in the death of from 25 to 70 per cent of the partly grown scales. We may hope that with the aid of this disease, and by means of the prompt introduction of its natural enemy, the fluted scale will never play the role in Florida which it originally did in California. The habits and transformations of the fluted scale closely parallel those of the species of Lecanium already described. The general appearance of the insect, however, is strikingly dissimilar, owing to the waxy excretions from the ventral plate of the adult female insect. These are ribbed, or fluted, from whence the insect takes its name, and becomes the receptacle of a vast number of eggs, a single female being the possible parent of more than a thousand young. The waxy material constituting the egg sac issues from countless pores on the under side of the body, especially along the posterior and lateral edges. As this secretion accumulates the body is lifted, so that ultimately the insect appears to be standing almost on its head, or nearly at right angles to the bark. The eggs are laid in the waxy secretion as it is formed, the waxy fluted mass often becoming from two to two and one-half times as long as the insect itself. The young are of reddish color, very active, and spread by their own efforts and by the agency of the winds, birds, and other insects. The female insect is, for the most part, a reddish orange, more or less spotted with white or lemon.

The early stages of the male are similar to the corresponding stages of the female. Before appearing as an adult, the male insect secretes itself in some crack in the bark, or in the ground, and exudes a waxy covering, which forms a sort of cocoon, in which the transformations are undergone, first into the pupa and then into the adult insect. The winged male is rather large for a coccid, and has a reddish body with smoky wings.

The rate of growth of the fluted scale is comparatively slow, and it does not normally have more than three generations annually. This insect is quite active, the female traveling and moving about very freely nearly up to the time when she finally settles for egg-laying. The male is active up to the time when it settles down to make its cocoon. The fluted scale exudes a great quantity of honeydew, and trees badly attacked by it are covered with the sooty fungus, characteristic of the black scale and the white fly.

The remedy for this scale insect is always and emphatically to secure at once its natural and efficient enemy, the *Novius cardinalis.* Where this insect can not readily be secured, the scale may be kept in check by frequent sprayings with the kerosene or resin washes. Fumigation is comparatively ineffective against it, because the eggs are not destroyed by this treatment. Spraying is, for the same reason, effective only when it is repeated sufficiently often to destroy the young as they hatch.

*The Mealy Bug.**—The mealy bug of the orange and other citrus plants is especially destructive in Florida and the West Indies. It is not of much importance in California.

* See illustration on page 195.

It occurs very commonly in greenhouses, and has been carried to every quarter of the globe. The insect is mealy white in color, the female attaining a length of nearly a quarter of an inch when fully adult. The edge of the body is surrounded by a large number of short waxy filaments. This insect is active in all stages and the eggs are laid in and protected by a cottony or waxy secretion, the female insect as this is developed being gradually forced from the bark, as in the case of the fluted scale. The adult winged male is light olive brown.

This species is somewhat gregarious and occurs in masses in the angles of the branches and leaf petioles and about the stem of the fruit. The remedies are the emulsions and oily washes, repeated as often as necessary to reach the young as they hatch.

The White Fly.—The white fly of Florida and the Gulf region is not a scale insect, but belongs to a closely allied family. In general appearance and habits, however, at least in its economic features, it exactly duplicates the true scale insects. For many years this very interesting insect has been known to infest the orange trees of Florida and Louisiana and also to be a common pest on the orange in greenhouses. It has been found also on a number of plants other than orange, such as viburnum, cape jasmine, and the aquatic oak of the South. These other food plants are of significance only in indicating that it may be harbored in situations near orchards in which efforts have been made to exterminate it. The first careful description of this insect and general account of its habits was given by Riley and Howard in 1893, and from their article the data following are largely derived.

The white fly is limited, economically, to the citrus plantings of Florida and the Gulf region. It is widely distributed in greenhouses, as already noted, and has undoubtedly been carried to California on many occasions, but has never gained a foothold out-of-doors. The dry hot season of southern California probably accounts for this, and may prevent its ever becoming troublesome in that region. Its origin is unknown. It first came into prominence about 1885, but probably had been present in greater or less numbers for a much longer period, and perhaps is native to Florida.

While closely resembling a scale insect in its early stages, the white fly in the adult stage emerges, in both sexes, as a minute white gnat, having four chalky wings of a fine granular texture, from which fact it is frequently called the "mealy wing." This active adult condition gives the white fly a distinct advantage over scale insects in means of spread.

The damage occasioned by it is greatly increased by the secretion, in the larval and pupal stages, of a honey-dew similar to that secreted by the true scale insects. This is in enormous amount, and the sooty mold which develops in it frequently covers the entire upper surface of the leaves and produces very serious effects on the vitality of the plant; the fruit does not ripen properly, is deficient in quality and size, and keeps poorly, involving in addition the expense of washing before it can be marketed.

The life round of the insect, briefly, is as follows: The winter is passed in the mature larval stage as a thin, elliptical, scale-like object on the under sides of the leaves. Early in the spring the transformation to the pupal stage occurs, this stage differing but slightly from the larval in appearance. The adults begin to appear by the middle of March and continue to emerge through April. The eggs deposited by this brood require about three weeks for development, hatching into larvæ from the middle of April to the 1st of May. The adults of the second brood begin to emerge by the middle of June and continue to appear until the middle of July. Between the middle of July and the middle of September a third brood is developed, the larvæ of which, hatching about the last of October, carry the insect through the winter. The number of eggs laid by a single female is in the neighborhood of twenty-five, and they are placed, by preference, upon new leaves, but all of the plant is taken when the multiplication of the insect makes it necessary. The young larva is active, resembling closely the larva of a true scale insect. The life of the adult ranges from ten to twenty days.

The most satisfactory remedies for this insect, as demonstrated by Messrs. Swingle and Webber, are the kerosene and resin washes and hydrocyanic acid gas. The treatments may best be made during the winter, between December and March, and again, if necessary, in May, and also in August or early in September. Two or three applications may be made in the winter. The application in August is made if the sooty mold is found to be spreading to the fruit. Since the insect lives on the under sides of the leaves almost exclusively, it is of prime importance that the under surface be thoroughly wetted with the spray, and it is necessary that the tree be opened up by pruning. Fumigation with hydrocyanic acid gas is also a ready means of destroying this insect. It is undoubtedly kept more or less in check by parasitic and predaceous enemies, and is subject to attack by several fungous diseases, which may be of occasional value in preventing its undue multiplication.

The Rust Mite of the Orange and the Silver Mite of the Lemon.—This mite is an enemy of both orange and lemon, affecting these fruits in a somewhat different way. For many years this mite was known only in Florida, and its injuries were notable only in the case of the orange. It is probably native to the Florida peninsula, possibly having originally some food plant other than the orange.

The lemon and orange groves of California were for a long time entirely free from the attacks of this mite, but about 1889 some carloads of citrus trees were taken into California from Florida and planted, without careful inspection, in the Rivera and San Diego Bay districts. This shipment of trees brought with it, unfortunately, two or three of the Florida scale insects, and also this rust mite, which has gained a foothold in the important lemon districts about San Diego, and is now one of the worst pests the lemon grower has to deal with. For a number of years the effect of its attacks in California was ascribed to a fungous disease, and it was not until the writer visited the lemon districts about San Diego Bay in 1896, and identified the injury as due to the Florida rust mite, that its true nature was known. Our knowledge of its life history and habits and the remedies for it are chiefly due to the work of Mr. Hubbard in Florida.

This mite develops on both the leaves and fruit, although its presence on the former is often overlooked. On the foliage the presence of the mite causes the leaves to lose their gloss and become somewhat curled, as though by drought. The leaves are never killed, however, the attack resulting merely in the considerable checking of the vigor of the plant.

The presence of this mite affects the fruit of the lemon slightly differently from that of the orange. The ripening fruit of the orange, after having been attacked by the mite, becomes more or less rusted or brownish, and the rind is hardened and toughened. While the orange loses its brilliant fresh color and gloss, the toughening and hardening of the rind enables the fruit to stand long shipment, and protects it very materially from decay. The quality of the juice is rather improved by the mite than otherwise, the mite-attacked oranges being more juicy and sweeter flavored. As a result of this, a demand grew up in the Northern markets for the rusty fruit, and good prices were obtained for it.

In the case of the lemon, however, an injury to the rind is an important consideration, a perfect rind being a requisite of the fruit, on account of the numerous uses to which the rind is put and the valuable products obtained from it. The effect on the lemon is also somewhat different from that on the orange. The rind of both fruits, when attacked by this mite in the green stage, becomes somewhat pallid or silvered due to the extraction of the oils and the drying up and hardening of the outer layer of the skin. This whitening is much more marked with the lemon than with the orange, and, since the lemon is often picked while green, the subsequent rusting is not nearly so notable; hence, in California this mite is known chiefly as the silver mite. If the lemon is allowed to fully ripen on the tree, however, it also becomes bronzed or rusted, but rather lighter in shade than the orange.

As in the case of the orange, the rind of the lemon is hardened and toughened, but the juicy contents are not affected materially; furthermore, a silvered lemon will keep very much longer than a perfect lemon, and will bear long shipment without risk of much loss. Until very recently the rusted lemon in southern California found no market whatever, and was a total loss to the grower. The scantiness of the crop in 1900 resulted, however, in some shipments of rusty fruit being made under the name of russet lemons, about half the normal price being obtained. Should the manufacture of citric acid assume very much importance in southern California, the mite-injured lemons could be used for this purpose. Nevertheless, considering the ease with which the mite may be controlled, there is no excuse for allowing it to maintain itself in injurious numbers in a lemon grove, since, irrespective of the appearance and value of the fruit, its work on the foliage materially lessens the healthfulness and vigor of the plant.

The rust mite avoids exposure to sunlight, and hence the lower half of the fruit is nearly always first invaded, and only gradually does the mite work its way around to the upper surface, very frequently a small portion exposed to the direct rays of the sun remaining unattacked. This gives the appearance, most prominently shown in the case of the orange, of a discolored band extending about the fruit. The multiplication of this mite goes on at all seasons of the year in the orange and lemon districts, being merely less prolific and active in winter than in summer. It has been supposed in Florida that dry weather is inimical to it, but the fact that it thrives in southern California would seem to throw doubt on this belief.

The rust mite itself is very minute, practically invisible to the naked eye. It is honey-yellow in color, and about three times as long as broad. It is provided with four minute legs at its head extremity, by means of which it drags its wormlike body slowly from one spot to another. The eggs are circular and are deposited singly or in little clusters on the surface of the leaf or fruit. They are about half the diameter of the mother and nearly transparent in color, having, however, a slight yellowish tinge. They hatch in four or five days in hot weather, but in cold weather the egg stage may last for one or two weeks. The newly hatched mite is very similar to the adult. About a week after hatching, it undergoes a transformation, or moult, requiring a period of about forty-eight hours, after which it escapes from the old skin, which remains adhering to the leaf or fruit for some little time. This moult brings the mite to its adult stage, in which it is somewhat darker in color than the young and opaque. No sexual differences have been discovered, and the number of eggs deposited by a single mite is not known. The entire development of the mite is short, probably not much exceeding, in warm weather, two weeks.

The food of the mite seems to be the essential oil which is abundant in all the succulent parts of citrus plants, and which is obtained by the mites by piercing the oil cells with their beaks.

These mites, while excessively minute, are capable of very active locomotion, moving from one part of the leaf to another, as the conditions of light and food necessitate.

An estimate, made from actual count, indicates that the mites and eggs on a single leaf in midwinter may reach the enormous number of 75,000. This indicates for trees, in the active breeding season of summer, billions of mites. The mite is very readily distributed by means of insects and birds.

The rust mite is readily destroyed by various insecticides. The eggs, however, are much more difficult to kill, and practically no wash can be relied upon to reach and destroy all the eggs of this mite. Experience in California indicates that gassing is also ineffective against the eggs. The sovereign remedy for the rust mite is sulphur. It may be applied as a powder on trees, and, moistened by rain or dew, will adhere to the leaves for quite a long period, not being readily washed off even by a hard rain. When spraying is done for scale insects, the flowers of sulphur can be mixed and applied with the spray, accomplishing both purposes

Curculio Catcher Made of Sheets on Frames. Used in Georgia. Dept. of Agr.

Wheelbarrow Curculio Catcher Used in New York [illegible]

at once. A better method, perhaps, is to first dissolve the sulphur with lye, as follows:

Mix 20 pounds of flowers of sulphur into a paste with cold water, then add 10 pounds of pulverized caustic soda (98 per cent). The dissolving lye will boil and liquefy the sulphur. Water must be added from time to time to prevent burning, until a concentrated solution of 20 gallons is obtained. Two gallons of this is sufficient for 50 gallons of spray, giving a strength of 2 pounds of sulphur and 1 of lye to 50 gallons of water. An even stronger application can be made without danger to the foliage. This mixture can also be used in combination with other insecticides.

There are several species of mites which attack citrus plants, the most troublesome one of which, especially in Florida, is the one named above. Almost any insecticide will kill the adult mite, such as kerosene emulsion, resin wash, or even a simple soap wash, but unless the eggs are killed the trees will be reinvaded about as thickly as ever in the course of a week or ten days. The advantage of the sulphur treatment arises from the fact that the sulphur adheres to the leaves and the young mites are killed as soon as they come in contact with it.

The Six-Spotted Mite.—This leaf mite or spider, is closely allied to the common red spider of greenhouses. It first made its appearance as an important orange pest in Florida in 1886. Following the severe freeze of the winter of 1885-86, the weakened trees seemed to be especially favorable for the multiplication of this mite; it increased suddenly in enormous numbers during the dry weather of the early summer and was responsible for very considerable damage to the foliage of the orange. The original food plant of this mite is unknown. It was first noted on wild orange, from which it spread to other citrus trees. It is probably a native of Florida.

Like its allies, this insect is greatly influenced by climatic conditions, and needs for its excessive multiplication dry hot weather. Therefore, in rainy seasons it is not especially troublesome, and it usually disappears as soon as rainy weather sets in. In Florida its period of greatest destructiveness falls between February and the middle of May. This mite was carried to California a decade or more ago with Florida stock, doubtless at the same time that several other Florida citrus insects were transported to the Pacific coast. In California, however, the principal mite injury seems to be due to an allied species, also brought from Florida.

The attacks of the six-spotted mite are confined largely to the under sides of the leaves, which are covered with a fine web, beneath which the mite feeds. The first indication of its presence is usually a yellowing in streaks and spots of the upper surface of the leaves. The under surface becomes soiled by the accumulated excrements in the form of minute black spots and by the web of the mite. On badly attacked trees the foliage curls and shrivels and the trees may lose half or more of their leaves, and similarly also a large percentage of the half-formed fruit. Being an accompaniment of drought in Florida, part of the damage may undoubtedly be ascribed to the effect of the dry weather.

The remedies are the same as for the rust of silver mite. The bisulphide of lime is also an effective wash. It can be made very cheaply by boiling together in a small quantity of water equal parts of lime and sulphur. Five pounds of lime and 5 pounds of sulphur, dissolved by boiling, should be diluted to make 100 gallons of spray. Gassing is ineffective.—(Farmers' Bul. 172; U. S. Dep. of Agr.)

The Orange Thrips.—This insect, a small, yellow, active insect belonging to the order Thysanoptera (popularly known as thrips), scars the fruit and curls and distorts the leaves of the orange. At the present time its control constitutes the chief insect problem confronting the citrus growers of the San Joaquin Valley orange belt of California, which winds along the Sierra Nevada foothills, from east of Fresno to south of Delano. This insect, the work of which was first noticed 15 or 16 years ago, has increased in numbers with the growth of the citrus industry and recently has assumed serious economic importance.

Injury to citrus trees and fruit is caused directly by the feeding of both adults and larvæ upon the surface of the parts attacked. This feeding may be on the young fruit, the nearly mature fruit, or the new, tender foliage, and generally takes place on all of these. The injury to foliage is generally on young leaves, but may also occur on the axillary buds.

The manner of feeding of both the adult and larva of the thrips is identical, and consists in piercing the plant tissues with the sharp mouthparts with which both stages are equipped and then rasping the wound by a rooting motion of the head. The vegetable juices thus liberated from the plant cells are sucked into the alimentary canal of the insect. The characteristic marking or scabbing of the fruit so noticeable at picking time, is started when the fruit is very small—just after the petals have fallen from the blossoms. This scabbed area is small at first, but as the fruit grows and the thrips continue to feed the markings deepen and at the same time the area of injury is enlarged. The continued feeding of a large number of thrips results in the scabbing of nearly the entire surface of the fruit. Often the marking is so large and deep over a portion of the orange that it causes the fruit to be misshapen and aborted. Frequently the entire surface is scarred while the fruit is still small, with the result that it ceases to grow and falls from the tree.

The orange thrips passes the winter in the adult state, and it is generally the adult form which first becomes conspicuous upon the orange trees in the spring. Although no large number of adults has been collected in hibernation, these undoubtedly pass the winter in sheltered places, such as the dead leaves and twigs forming the trash under most orange trees; they are occasionally found on living plants and on citrus nursery stock in midwinter.

In view of the success attained in reducing injury to fruit and foliage by the orange thrips, it is believed that it will be possible to control this species in normal seasons with four applications of lime-sulphur combined with blackleaf tobacco extract.

Three of the treatments should be made in the spring to free the fruit and spring growths of foliage from injury, since the more severe marking of fruit is done while the fruit is small. The fourth treatment should be made in August or September, according to season, for the protection of the later growths of foliage, and should be timed to catch the thrips when numerous, but before the leaves show much curling. The three spring applications should be made about as follows: First. Just after most of the petals have fallen from the blossoms; Second. Ten to fourteen days after the first; Third. From three to four weeks from the time of the second treatment. The dates for spraying in any given season must be timed by the abundance of thrips.—(U. S. D. A., B. E. Bul. 99, Part I.)

The Red Spider of Citrus Trees.—Red spiders have been injurious in southern California for many years, but little attention has been given to the matter, chiefly on account of the extremely minute size of these creatures. The appearance of the fruit from trees badly infested with the red spider is very characteristic, and easily recognized when once known, but has not, as far as we can learn, been taken into consideration in the grading of fruit. Should the market come to recognize and begin to discriminate against the paler fruit, upon which the mite has been at work, the losses would become very large.

Upon hatching, the creature which appears resembles the adult mite very closely except in size and in the absence of the hind pair of legs, making the number six, thus resembling insects to this extent. Many other mites are six-legged when first hatched from the egg. The young red spider at once begins to feed and is very soon ready to prepare for the change of skin which results in the assumption of the fourth pair of legs. The juices of the leaf are sucked up through a tube-like cavity between the palpi; and where each slit is made and the contents pumped out a paler spot remains.

A material that is both safe and effective is the *sulfid of potash spray mixture.* This mixture is usually made according to the following formula:

Potash	32 lbs.
Sulphur, finely ground	37 lbs.
Salt	2 lbs.
Water	50 gal.

This makes the stock-solution which is diluted with about a hundred times as much water for spraying. The potash, sulphur, and salt may be mixed together in a large metal tub with a little water, when chemical action will at once set in and the whole mass will dissolve and begin to boil very vigorously. After the boiling has ceased, the water is added and the stock-solution is made. It is very doubtful whether the salt is of any value in this mixture, but it can at least do no harm as it is in such small quantity. This sulfid of potash is of very little value, at least at this strength, as an insecticide, but is effective enough against the active stages of the mite. In order to kill the eggs and moulting forms it will be necessary to make three applications, separated by intervals of one week. This will make a very clean sweep.—(Bul. 145, Cal. Agr. Exp. Sta.)

The Scale Insects of the Date Palm.—To the naked eye the scales appear as small dark-grey or black specks, edged with white, At one end will be seen a small oval object, which is the first skin; that is, the skin shed by the young at its first moult. The large shield-shaped object is the second skin, and the white surrounding part is the scale secreted by the insect in its last stage. The date scale when once established, spreads rapidly, damages the foliage of the date palm and renders the fruit unmarketable, being therefore a serious menace to the industrial future of the tree under our climatic and cultural conditions. Fortunately, however, the limited size of the broods, insect enemies, the probably wingless condition of the male, and the fact that this scale so far as now known has no other food plants in this region, all tend to limit the numbers and range of the insect. For remedies see under heading of the Marlatt Scale.

The female insect is from 1 to 1¼ mm. long, and secretes a white waxy substance but does not produce any true scale like that of the *Parlatoria.*

The Marlatt Scale, because of its closer confinement to the bole of the palm, is comparatively harmless and to be regarded with less apprehension.

To free the palm trees of these two scales, first cut back close to the bole all old leaves that are badly infested and then thoroughly go over the trunks and leaves with the flame from a gasoline torch.

With the radical and thorough method of treatment by burning at command, described above at the same time fatal to scale insects and not seriously injurious to the palms, and with a suitable law for the application of the method, there is no reason, except lack of vigilance, why the scale insects affecting date palms may not now be considered under control in Arizona. (Bul. 56 Ariz. Exp. Sta.)

The Pineapple Scale.—This pest of the pineapple is a scale insect, one of the Coccidæ, which, because of its special fondness for this plant, has received the common name the "Pineapple Scale."

These small, scale-like insects are very conspicuous, because of their color, and not easily mistaken for other forms. The scale and not the insect itself is the object commonly seen. The insect is found beneath this secretion, which serves as a shield. In the case of this insect the scale or protective armor is made up partly of a waxy secretion of the insect and partly of molted skins. The insect itself in the adult stage is quite well buried beneath the epidermis of the plant and hence the necessity of combating the pest in its early stages.

The pineapple scale can be controlled by spraying where it occurs in the field with kerosene emulsion or the resin wash, 1 part to 10 of water. The cheaper and easier method is by proper preventive measures to keep the pest from gaining a foothold in the plantation. These measures are to burn all leaves where the pest is at all evident after harvesting the crop, to dip young plants in an insecticide before planting, and to produce the maximum vigor and health of the plants by thorough cultivation and fertilization. In the question of the control of the insect pests and diseases of plants, no one point is more important than vigorous and clean cultivation and the proper supply of plant food and moisture. It is an accepted fact in applied entomology that a healthy growing plant is capable of offering resistance to the attack of an insect pest. (Press Bul. 10, Hawaii Agr. Exp. Sta.)

The Mango Weevil.—The destructive work of the mango weevil in the seeds of mangoes was noted in Hawaii for the first time last year. The nature of the insect and its injury point it out to all persons interested in the culture of the mango as a serious pest.

As a beetle, the mango weevil has a thick pair of wing-covers which, when folded together at rest, give the body the appearance of a shell. The wing-covers are much rounded and extremely hard. As a weevil, the head is prolonged in front into a beak or rostrum, bearing the antennæ on its sides and the modified mouth-parts at the extreme end. The mouth-parts are formed for gnawing. In the mango weevil, the beak is short and thick and when at rest is turned back beneath the thorax in a groove terminating between the first pair of legs. The adult weevil varied from ¼ of an inch to 5-16 of an inch in length in the specimens measured. When newly developed, the adult is a whitish pink in color, but soon changes to a dark brown with yellowish markings.

The beetle feigns death on being disturbed and drops to the ground with the head drawn well under the thorax and the legs folded beneath the body. Its protective resemblance to coarse earth and debris is particularly noticeable. Nothing has been observed in regard to the food habits of the adult.

The eggs of the mango weevil were found on mangoes from one-half to three-fourths fully grown, situated alongside a slight incision on the rind. The writer has not observed egg-laying or carefully noted the habits of the weevil as regards oviposition, but is inclined to think that the eggs in the instances seen were probably placed within the incision or cavity and later forced out by the exudation of juice, an amount of which in a dried condition enveloped them.

The larvæ in appearance are, generally speaking, like the sugarcane borer, that is, footless, "fleshy" grubs, light in color, with a dark head. The entire development after hatching from the egg is undergone within the seed. When fully developed, the larva constructs a pupal cell, surrounded simply by the excrement, within the tunnel formed by feeding, and transforms to the pupa. The inactive pupa is perfectly white in color with the developing head, legs, wings and body-parts plainly indicated.

Since the mango weevil is a special feeder on the seed of the mango, its numbers in any particular season are in direct proportion to the size of the mango crop for that season. That is, when the mangoes are abundant, the brood of weevils arising from the fruit will also be large in numbers. Any natural condition of climate or disease that affects the mango crop will likewise reduce the numbers of the mango weevil.

The fact that the weevil during its entire development is within the seed renders the use of any insecticide impossible in combating the pest. Since also there is practically no exterior evidence that the fruit is infested, little can be done in the destruction of infested fruit during the growth of the crop.

The destruction of all fallen mangoes and refuse seeds will be quite effective for the reason that the adult beetle does not leave the seed until some time after the maturity of the fruit.

The burning. of all refuse about the mango trees during the months from October to March would destroy many of the hibernated weevils.—(Press Bul. 17 Hawaii Agr. Ex. Sta.)

THE NUT WEEVILS.

The Larger Chestnut Weevil.—The larger chestnut weevil is considerably the larger and more robust species. The female rostrum or beak, although proportionately of about the same length as in the lesser weevil, is perceptibly more prominent because less curved, the curvature being toward the tip. It is also more widened at the base. The body measures from one-third to nearly one-half of an inch in length, and the beak of the female is often five-eighths of an inch long. That of the male is nearly as long as the elytra. The egg is small, about one-sixteenth of an inch long. It is nearly white, partially translucent, and without sculpture.

The larva is milk-white, robust, fully three times as long as wide, with the dorsal or upper portion rounded and convex. The entire surface is very strongly wrinkled transversely, and there are a few very short hairs scattered sparsely over the different segments. The head is about one-fourth as wide as the widest portion of the body. It is provided with short but strong mandibles, by means of which it gnaws the kernel constituting its food. The fully developed larva in ordinary resting position measures nearly half an inch. Although the larva has no true legs, it is able to crawl, slowly and clumsily, it is true, by means of the flattened lower surface, locomotion being aided by transverse wrinkles.

The pupa is of a clearer whitish color than the larva, and shows the principal external organs of the body of the future beetle, all, except the beak, folded tightly to the body.

This species, like the other weevils under consideration, is native to America and is known from Rhode Island to Virginia, the District of Columbia, southern Ohio, and Tennessee, and westward to Kansas. The geographical distribution of this and the other nut weevils has as yet not been carefully studied, but in all probability it is considerably more extensive than above stated.

In some regions this species is quite generally known as the chinquapin weevil, but the investigations conducted during 1904 indicate that, although it breeds in chinquapins and more commonly in chestnuts, it occurs in greater abundance in the larger imported nuts.

The Lesser Chestnut Weevil.—The lesser chestnut weevil has the scape of the antenna longer than in the preceding species and the first joint longer than the second. The average length of the body is about one-fourth of an inch, but the size varies, as in all of these insects.

The distribution of this species extends from Canada and Massachusetts to North Carolina, Tennessee, and Ohio, and probably farther westward. The investigator has seen sets of specimens labeled Arizona. Although in some localities the larger species is much more in evidence, taken all in all, the lesser weevil is the more common and is probably even more widely disseminated.

The egg has not come under observation, but is undoubtedly very similar to that of the preceding, being proportionately smaller, which is true of the remaining stages. The larva is only a third of an inch long and its length is about three times its width. The body is milk-white and the head light brownish yellow, while the λ-mark has a short lateral branch each side. The pupa differs from that of the larger species by size.

The life history of our two chestnut weevils is so similar as to be practically the same for both species. There are, however, minor differences. These, as well as related nut and acorn weevils, hibernate exclusively in the larval condition and in the soil. Both make their first appearance at about the same time—with the first blooming of chestnuts—but this period may vary from late in June to July, according to locality and season, or, more properly speaking, the mean temperature. At this time the beetles are found rarely and scatteringly, and as oviposition has not been observed then it is doubtful whether it begins until considerably later. What function these early arrivals fulfill is problematical. The beetles increase in number as the nuts approach maturity, or until about the middle of September or a little time before the nuts are first marketed. Then they may be seen in greater abundance, several pairs, frequently of both species, often occurring on a single bunch of burrs. As it requires about two weeks for the egg to develop, it is not probable that they are laid much earlier than when the nut begins to form.

Eggs are laid singly, but many are placed in a single nut, as high as 40 or more (of the smaller weevil) in imported nuts, and as many as 9 in native nuts. The larvæ when hatched feed on the tissue of the growing kernels, enlarging with their own growth the cells thus made.

Rarely larvæ bore through the burr. On leaving the nuts they burrow into the earth to depths varying from 2 to about 8 inches, according to the hardness of the soil. If confined in soft earth or sand they penetrate still deeper. The larval period probably lasts from three to five weeks in the nuts, and about ten months in the earth, pupation taking place within three weeks of the issuance of the beetle, the latter remaining several days in the earth before appearing above ground.

The most practical remedy for nut weevils that can be suggested is the early destruction of the worms in the nuts by means of bisulphid of carbon and the observance of clean orchard management and other cultural methods. It may be well to preface the discussion of these methods with a statement of the uselessness against nut weevils of ordinary measures employed in the control of similar insects.

The value of bisulphid of carbon as a fumigant for chestnuts infested by weevils is now fully established. Although at first thought it would seem difficult for the gas to penetrate through shells so firm and compact and kill the larvæ, nevertheless a prominent grower in Pennsylvania successfully uses the bisulphid, applying it when the nuts are first harvested. The dead weevil larvæ are at this time so small that the average person would never detect their presence, while if they were permitted to develop they would soon destroy the nut for food. Bisulphid of carbon has been used on the largest chestnuts grown in this country, and, since a score or two of larvæ find shelter in a single nut, one can appreciate the desirability of prompt fumigation. The grower mentioned uses bisulphid of carbon at the rate of 1 ounce to a bushel of Paragon nuts placed in a kerosene barrel of about 50 gallons capacity and covered by sacking. After an exposure of about sixteen hours the nuts are removed, the larvæ being then practically all destroyed. Some growers make a practice of plunging the nuts as gathered into boiling water just long enough to kill the contained insects and yet not injure the nuts for sale, after which they are dried before being marketed. This may be profitably accomplished by using a large sieve, which is filled with nuts, dipped in the water, and removed in about five minutes.

Different methods are employed in drying. A good way is to place the nuts in the sun and agitate them occasionally by stirring or shaking in a bag until thoroughly dry, because if moisture remains unevaporated it is apt to form mildew when the nuts are prematurely packed for shipment.

Nuts for planting should not be scalded, and care should be taken not to cook the kernels of nuts intended for sale. Some growers claim that the hot-water treatment is objectionable because the nut-shells lose a certain degree of polish, rendering them less desirable for market. Infested nuts can be subjected to a temperature of between 125° F. and 150° F. without injuring them for food or for seed, and this will effect the destruction of the larvæ within. Some growers of chestnuts destroy the weevils by kiln-drying.

Cold storage has been employed and is successful in arresting the development of the larvæ. The appearance of the nuts is scarcely different from that of those not so stored, but nuts thus treated and submitted to the writer after becoming dry were deficient in flavor, having an acrid and moldy taste. A crude form of cold storage has been successfully followed by a Virginia grower. It consists in placing nuts in the earth under the shade afforded by his house, where the soil temperature, after the nuts are gathered, does not exceed 50°. Since most insects are inactive below 51°

this has the effect of restraining their development, causing the eggs or minute larvæ to die.

It is always advisable to gather the entire crop, leaving none on the ground, and either place the nuts in tight receptacles or fumigate with bisulphid of carbon before marketing. The grubs crawl out soon after the nuts have been gathered, and as they require considerable moisture they will die if confined in closed barrels or boxes. The trouble is that enough nuts are usually left in orchards or in adjoining wood or forest land to serve for the propagation of the insects the following year. In order to make the method of treatment here described thorough, it will be necessary to secure the co-operation of neighboring landowners who grow chestnuts for market and of all who own woodland containing chestnut and chinquapin.

The collection of remnants can be made by children or the unemployed. It is also profitable to allow hogs the run of the orchards to destroy what nuts remain after the crop has been harvested. In the mountainous sections of Virginia and Pennsylvania it is a common practice to fatten swine on the unpicked fallen nuts. Hogs fatten on nuts and acorns as well as on corn, and without expense to the grower.

The Pecan Weevil.—With the increase of pecan culture in our southern States frequent inquiry is made in regard to the cause of the holes in the nuts and during 1903 and 1904 there were reports of great injury of this nature, more particularly to pecans grown in Texas, where considerable loss was reported, and in Georgia, where in one locality 75 per cent of the crop was a failure. A shortage has also been reported in Mississippi. The insect involved in these cases is the pecan or hickorynut weevil, a pest which is evidently destined to become one of the principal drawbacks to the cultivation of the pecan. Indeed, in many parts of the South it already divides that distinction with the husk-worm, so that it has been truthfully said that what the husk-worm leaves the weevil destroys.

The beetle is about the same size as the larger chestnut weevil, from which it may be distinguished by its much duller color and by the relative lengths of the first and second antennal joints, the first joint being longer than the second in the pecan-infesting species.

The larva differs from that of *proboscideus* in being decidedly yellow, having the head bright red and wider than long. Its cervical plate also is darker. The pupa is similar to that of the larger chestnut weevil.

The distribution extends from New York to the Gulf, and westward at least to Iowa.

The life history of this weevil, as it occurs in the pecan in the South, is, so far as can be gathered from reports from Georgia and Texas and from laboratory experiments, very similar to that of the chestnut weevils. According to the observations of Mr. H. A. Halbert, at Coleman, Tex., the female begins to deposit her eggs in August while the pecan is still immature, and the larva usually escapes from the nuts in the latter part of September and in October; but most of them do not issue until the husks open, allowing the nuts to fall. In Georgia they have been found in the nuts as late as the middle of January.

The same care in the selection of the site for a pecan orchard is advised as in the case of chestnut culture, with this difference, that the grower should avoid planting in the vicinity of wild pecan and hickory of whatever kind. The entire crop, also, should be harvested or hogs should be turned in to devour what nuts are left. Where swine and chickens have access to a pecan grove, the ground is well rooted and scratched up and there is less loss from weevils than in the previous year. Evidently both hogs and poultry devour the larvæ in the ground.

At the time that bisulphid of carbon was first suggested as a remedy for chestnut worms it was feared that the firm and compact shell would hardly permit the gas to penetrate and kill the contained larvæ. Experience, however, has shown that this remedy is successful in the case of chestnuts, and it is not impossible that it might be adapted to pecans, using a larger amount of the chemical and a longer exposure in a perfectly tight receptacle. We can as yet scarcely advise this method on a large scale, but it should certainly be tried experimentally.

The Hazelnut Weevil.—Hazelnuts or filberts are injured in much the same manner as are chestnuts and pecans and by a similar weevil. Injury was recognized as early as 1841, but was attributed to other species than that under consideration. Owing to the comparatively slight importance of the hazel as a nut tree in this country, few notices of losses from weevil attack have been recorded. The weevil which affects the nut was not differentiated from others of its kind until 1884. In 1891 it was reported as badly damaging hazelnuts in Iowa.

The beetle differs from others which attack edible nuts, exclusive of acorns, by its shorter, more robust form and shorter beak. It is about one-fourth of an inch in length, and the beak does not exceed half the length of the body. The vestiture varies from gray to ochreous, and the elytra are moderately mottled.

This species occurs from Massachusetts and New Hampshire westward to Minnesota and Texas. Injury has been noted in Massachusetts, New York, Indiana, Iowa, and Minnesota. Of the life history little has been recorded beyond the fact that the worm issues from the side of the nut, and that paired adults have been found on hazelnuts in July.

Since hazels are not cultivated in this country to any extent, no remedy need be employed other than gathering entire crops and destroying isolated bushes where it is unprofitable to gather the nuts. It would be quite possible, owing to the small size of the hazel plant, to control this species by jarring, as for the plum curculio.—(Cir. 99, B. E., U. S. Dep. of Agr.),

The Pecan Cigar Case-Bearer.—Among the insects of minor importance that affect the pecan, the pecan cigar case-bearer is probably met with in groves more than any other species. At times the insect occurs in such numbers as to defoliate entire trees, checking their growth and considerably reducing the crop of nuts. In the future this insect is likely to cause increasing damage as the acreage in pecans increases.

Damage by the pecan cigar case-bearer occurs during the early spring, principally to budded trees, and is due to the feeding of the larvæ on the tender buds and unfolding leaves. Where this insect is very abundant it causes injury in two ways. If the buds are backward in opening, the larvæ leave the twigs where they have hibernated, and crawling to the swelling buds attack them and eat out the contents, so that the life is destroyed, and before the tree can put out its foliage the dormant buds must develop. On the other hand, if the trees develop their foliage before the larvæ leave hibernation in injurious numbers, the leaves are riddled by the larvæ as they come from the twigs and the wind soon whips them to pieces. The adult is a delicate little moth, ochreous in color with a wing expanse of about 1-3 of an inch.

The larva is about 1-5 inch in length, brown in color. The moths emerge from the pupæ during May and June, and at that time may be found among the pecan trees.

The larvæ upon hatching from the eggs in July, mine the leaves of the host plant, and after feeding there for some time cut out the two skins of the mine and construct the cases within which they live during the fall and winter. After the cases are made the larvæ feed upon the leaves by eating through the lower epidermis and tunneling out the interior of the leaf in all directions until the mine is so large that to mine farther the larvæ would have to leave their cases. Under such conditions they move and begin a new mine, so that the leaves become full of irregular rectangular patches of brown with a small round hole in the center on the underside. In feeding, the larvæ carry the cases nearly perpendicular to the leaf surface.

Where this insect becomes abundant enough to be injurious it can with little doubt be controlled by spraying the trees with arsenate of lead (at the rate of 3 pounds to 50 gallons of water) when the buds are swelling—in March in central Florida and in similar climates. When the larvæ attack the foliage, this should be similarly sprayed. Lime-sulphur mixture applied during the dormant season would undoubtedly give good results.—(U. S. D. A., B. E. Bul. 64, Part X.)

The Pecan Bud-Moth.—In some orchards the depredations of this insect, combined with the damage inflicted by the case-worm, cuts off one-half the yield of nuts. The moth is about ⅝ of an inch in wing expanse; color grey. The pupa is light-brown in color, ¼-inch long and is encased in a tube of dead leaves lined with silk. The larva is slightly more than ½-inch long, light yellowish green. The minute eggs are deposited on the under side of the leaf. Upon hatching the young caterpillars at once commence feeding on the outer skin of the leaflets, on the under side. The larva soon constructs a silken tube from which it does all its feeding thereafter. The damage is to the under surface only and causes a brown patch to appear.

Lime-sulphur spray used as for the San José Scale, during the dormant period offers the best chance of success, fully combatting this pest.—(Bul. 79 Fla. Agr. Exp. Sta.)

INSECTS AFFECTING VEGETABLES.

GENERAL PESTS.*

Before taking up in order the insects that attack the various plants grown in our vegetable gardens, attention may be drawn to a number of kinds that are general feeders, not limiting themselves to any particular varieties, but attacking almost everything that comes in their way; on that account they are the most serious foes that we have to contend against and in many cases the most difficult to keep under control.

Aphids (*Plant-lice*).—These are minute pear-shaped, soft-bodied insects that may be found on almost every kind of plant, usually in dense colonies clustered thickly on the terminal twigs and buds, on the under-side of leaves, on stems and other parts, and even under ground on roots. Wherever situated they are occupied in the same manner—sucking out the life-juices of the plant and multiplying their own numbers by constant reproduction of living young all through the summer. There are a great variety of species, most of them varying shades of green in color, some are shining black, others bright red; some again are covered with waxy filaments resembling threads of cotton wool, and others with a dusting of a mealy substance composed of the same material. Singly they are insignificant creatures, but occurring as they do in enormous numbers and multiplying with amazing rapidity, they are able to seriously injure and often to destroy the vegetation that they attack. Fortunately they are devoured by many predaceous insects, such as lady-bird beetles and their larvæ and those of lace-winged and syrphus flies and other creatures washed off and drowned by heavy rains, and reduced in numbers by internal parasites; otherwise they would in time destroy all vegetable life. Ants are usually to be found prowling about the colonies; they do not eat the Aphids, as might be suspected, but are attracted by the sweet honey-dew that exudes from them, and take them under their special protection.

In gardening operations nature's checks are not sufficient, but require to be supplemented with artificial remedies such as kerosene emulsion, strong washes of soap-suds or tobacco decoction. In greenhouses they can be kept in control by burning the commercial preparation of tobacco.

Ants.—These insects are often suspected of injuring the plants over which they are seen running, but as a rule they are only indirectly responsible. A few species, such as the large black Carpenter Ants, form their galleries in trunks of trees, posts and timber and do

*Except where specially noted otherwise all extracts concerning vegetable insects are taken from Bul. 171, Ontario Dept. of Agr., Ontario Agr. College.

a considerable amount of damage, but the great variety of smaller species which infest our gardens do not feed upon foliage or injure growing plants. Sometimes they may be found upon unopened flower buds, but they are only attracted by some sweet secretions on the surface; as a rule their presence indicates that there is a colony of aphids near by, which they take under their protection in order to obtain from them the sweet honey-dew exuded by these minute creatures. The worst injury for which they are responsible is the establishment of colonies of Aphids upon the roots of many plants; the ants collect the eggs and take care of them during the winter and when growth is sufficiently advanced carry them to the roots and look after them during the summer, in order to have a constant supply of honey dew. These colonies increase rapidly, soon check the growth of the plant and ultimately destroy it. Where ants' nests abound, frequent digging and stirring of the soil, and in field cultivation repeated disking and harrowing, will get rid of many, or they may be treated with carbon bisulphide; a small quantity should be poured into the entrance of the nest or into a hole made with a stick and quickly covered with earth; the fumes will speedily kill all the inmates. It is best to perform the operation towards evening when all the ants are within the nest. This is a very effective mode of getting rid of the large colonies which make mounds of rubbish on lawns and in fields.

Cutworms.—At the beginning of the growing season the gardener often finds in the morning young plants cut off near the surface of the ground that the evening before were strong and healthy. On stirring up the soil near by he may find hidden in the ground a greasy-looking caterpillar, the culprit in the case. Cutworms, so called from this habit, are the caterpillars of dull-colored night-flying moths of a great variety of species and varying to some extent in their habits. As a general rule they are partly grown at the approach of winter and hide away in a torpid state during the cold weather; when restored to activity by the warmth of spring, which causes the buds to open and the growth of plants to begin, these worms come out in search of food and attack any kind of tender vegetation they meet with. They are nocturnal in their habits and hide away during the hours of daylight under any shelter they can obtain or just below the surface in the loose soil of newly made beds. Owing to their destructive practice of cutting off a whole plant in order to devour a portion of its foliage, they do a great deal of apparently needless damage.

After they have become fully grown they change to the chrysalis stage in the ground and in early summer the moths appear, many of them making their presence known in our houses by their attraction to light. Before very long another brood of caterpillars comes upon the scene, often more numerous and more destructive than the first. Some of them climb up into fruit trees and destroy the foliage, others attack farm crops, vegetables, grape vines, the plants in flower gardens, etc., while occasionally a single species appears suddenly in enormous numbers and sweeps like an army over the land devouring everything that comes in its way.

Happily a very simple and completely effective remedy has been found for these destructive creatures. It is called the poisoned bran-mash and is made in the following manner: Mix half a pound of Paris green in 50 pounds of bran (the proportion for larger or smaller quantities is 1 to 100); the poison should be added to the dry bran little by little and stirred all the time till the whole is tinged with the green color, then add water sweetened with sugar, or molasses, till the mixture is sufficiently moistened to crumble nicely through the fingers. If bran cannot be procured, shorts or flour may be used, and for field work may be distributed dry by means of seed drill. The mash should be scattered about the plants that are liable to attack in the evening, and strange to say the worms will devour it in preference to their ordinary vegetable food. When they begin to feel the effects of the poison they wander off to find a hiding place or burrow in the ground and there die. Their dead bodies will be readily found in the morning just below the surface of the ground, often in surprising numbers. Young plants, such as cauliflowers, tomatoes, etc., may be protected when set out by wrapping a bit of newspaper around the stem between the root and the leaves and reaching a little below the surface of the ground. The worms will not attempt to bite through or climb over it.

Flea-Beetles.—There are several species of these minute insects which attack a large variety of plants; some confine their attentions to one or two kinds, while others are general feeders. The beetles are about one-tenth of an inch in length, oval and convex in form, usually shiny black or bronzed in color, sometimes ornamented with broad, pale stripes along the back; they all possess enormously developed thighs on the hind legs by means of which they are enabled to jump with great agility and hence have acquired the name of Flea-beetles. They appear in early spring, often in large numbers, and eat small holes in the foliage of young plants, preferably the thick seed-leaves. The larvæ, as far as known, feed for the most part on the roots of weeds, as well as upon some garden vegetables; clean cultivation, especially of fence corners and bits of waste land, is therefore of much importance in the control of these and many other kinds of insects. The beetles may generally be found all through the summer when they especially attack the foliage of potatoes, turnips, beets, tomatoes, and many other plants. In many cases, fungous diseases, such as potato blight, find suitable places for the growth of their spores in the holes made in the leaves by these beetles.

Cheese-cloth screens are very effective in warding off attacks upon young plants, such as cucumbers, etc., but where their use is not convenient or practicable the beetles may be controlled by the use of the poisoned Bordeaux mixture, the combination being effective against both the insects and the fungous diseases. For tender foliage arsenate of lead is preferable to Paris green as it is not so likely to cause injury by burning.

Grasshoppers (or Locusts, as they should be called).—These are often very destructive in the later summer months, especially if the weather should be dry and hot. They are general feeders, few kinds of vegetation coming amiss to them when they are numerous and the supply of food at all scanty. Usually they are most abundant in dry pastures and the neighboring grain fields; this is due to the fact that their eggs are laid in grass lands, especially where the soil is dry and sandy, and the young nymphs grow there to maturity. They do not pass through any chrysalis stage, but gradually become bigger after each moult till the full-winged adult state is reached. Many mechanical devices have been employed for their destruction, but the use of these troublesome methods can now be dispensed with since the discovery of the Criddle mixture, a poisoned bait which derives its name from Mr. Norman Criddle, of Aweme, Manitoba, who proved its complete efficiency after a series of experiments. It is made and applied as follows: Take a three-gallon patent pail and fill it with fresh horse droppings, then empty into a barrel; repeat this five times. As each pailful is poured in, mix thoroughly with the manure about a quarter of a pound of Paris green and half a pound of salt which has been dissolved in water. There would thus be used about one pound of Paris green and two pounds of salt to half a barrel of manure. The mixture may be drawn in a cart to the infested places and scattered broadcast with a trowel or wooden paddle. The grasshoppers are attracted to it from considerable distances and are killed in large numbers. It has been found most effective to distribute the mixture on alternate days, a little at a time, rather than to use larger quantities at longer intervals. In the case of grain fields, oats being especially liable to attack, the mixture should be thrown into the grain along the sides of the field and the grasshoppers will eat it in preference to anything else. Care should be taken not to allow cattle or poultry to have access to it.

Plant-Bugs.—In the American use of the word the name Bug is erroneously applied to insects of every kind—to a beautiful butterfly or moth as well as to a disgusting bed-bug. The name, however, when correctly employed denotes insects belonging to the order Hemiptera, which are provided with sucking and not biting mouth-parts, and which do not pass through any quiescent chrysalis stage but are gradually developed from the newly hatched larvæ to the winged adult. To the true bugs belong two species which are very abundant in gardens, attacking plants of all descriptions, flowers and vegetables alike. These are the Tarnished and the Four-lined Plant-bugs.

Tarnished Plant-bug.—This is to be found all through the season on plants of almost every kind, sucking the juices of flower buds and foliage and sometimes of the leaves of young fruit trees. The mature insects are oblong in form with a triangular head and prominent eyes, and tapering to a rounded angle at the tail. The color is variable, usually grayish brown, marked with yellowish and black dashes, and having a slight bronzy reflection; its length is a little over a quarter of an inch. They are very active insects, taking flight readily when disturbed, or dodging round to the other side of the plant.

Four-lined Plant-bug.—This is much the same size and shape as the preceding, but is yellow in color, with dark lines down the back and four black dashes along the thorax. Its attacks are most noticeable in early spring, when it may be found on mint, sage, currant and gooseberry bushes, and often also on potatoes. It sucks the juices of the tender terminal leaves, causing them to shrivel up and turn back, and frequently severely injuring the plant. The standard remedy for these and other sucking insects is spraying with strong kerosene emulsion; where this cannot be applied, as in the case of many flowering plants, dusting with pyrethrum insect powder has been found quite effective. Much may be done by knocking off the bugs with a stick into a pan containing a little water covered with a film of coal-oil; this should be performed in the cool of the morning when the insects are less lively than during the heat of the day.

White Grubs.—These are the larvæ of May-beetles or June-bugs which breed for the most part in old pastures. The beetles appear about the end of May or early in June and attack the tender foliage and buds of fruit and ornamental trees, often inflicting a considerable amount of damage. They come out at night and swarm about the trees, making a loud buzzing noise: many are attracted by lights in houses and cause some consternation among the inmates through their clumsy flight about the room and the noise that they produce; as they can neither sting nor bite no alarm need be caused by their presence. During the night they feed and by morning all disappear, hiding underground where the soil is loose and under grass or rubbish about fences and buildings. At this period boys might be employed to search for and kill them; trap-lanterns have sometimes been used with advantage, and spraying the trees they frequent with Paris green will destroy large numbers. The beetles deposit their eggs on the stems or roots of grasses just below the surface of the soil; from these the grubs hatch out and feed for two or three years underground. During the summer of their third season they change to the pupal state and transform to beetles about September, but do not come out until the following spring. This long larval stage accounts for the fact that in some localities the beetles only appear once in three years.

The grubs, when fully grown, are thick, fat creatures, white in color—hence their name—with the body partially curled up and the last segments discolored from the food showing through the skin. When an old pasture is broken up they live for a time on the grass and roots that have been turned under and then attack whatever plant may be grown. The first and second crops usually suffer most, especially strawberries and corn; clover is least affected by them and may be seeded down with rye, then small grains followed by corn or potatoes. Late and deep plowing will break up the winter quarters of the grubs and beetles and expose them to frost and also to the various animals that prey upon them. Pigs and poultry greedily

Spraying Apparatus Used in Hopyard in British Columbia. Dept. of Agr.

devour them; crows and other birds and skunks also destroy large numbers when they can get access to them.

In gardens digging deeply and trenching in the fall is very useful, but in the flower beds where perennials are grown this is impracticable, and therefore recourse can only be made to disturbing the soil between the plants as much as possible in late autumn and early spring. Lawns and golf-links are frequently very badly affected as they are left for many years undisturbed; sometimes the roots of the turf have been so completely eaten off that the sod may be rolled up like a carpet. In such cases the best plan is to dig up the part affected and destroy the grubs, put in a fresh layer of soil and resod or sow with grass seed. For small patches, watering with kerosene emulsion, and washing it well in with plenty of water from the garden hose, will kill the grubs. Where large areas are found to be affected on golf-links or in pastures, the most effective plan is to enclose the place with hurdles and turn in a few young pigs; they will soon root out and devour all the grubs, and may then be removed to another spot.

Wireworms are the larvæ of Click-beetles, so called from their curious habit of springing up in the air with a click when laid upon their backs. The beetles are long and narrow, rounded above, with very short legs and usually dull gray or black in color. The grubs are long and cylindrical, with a very hard integument from which they get the name of Wire-worms, and yellow or whitish in color. The life history is very similar to that of the White-grubs; they breed chiefly in old pastures, take two or three years to mature, and feed upon the roots of any plants that may be convenient to them; they are especially injurious to corn, and often may be found during the winter feeding inside potatoes in which they burrow great holes. No treatment of the soil with salt, poisons, etc., has any effect upon them; the only remedy is a short rotation of crops as in the case of White-grubs; plowing in August and cross-plowing again in September will destroy large numbers of them. In gardens, as the beetles usually spend the winter under any shelter they can find, clean cultivation, especially along the fences, is of great importance; in spring many may be destroyed by placing bunches of clover or weeds poisoned with Paris green under shingles or bits of board where the beetles go for shelter.

ASPARAGUS.

Asparagus Beetles.—The two species, the Blue and the 12-spotted, have spread over a great part of Ontario during the last few years and in many places are very abundant. Both species are often to be found upon the same plant; the former is shining blue-black in color with creamy-white blotches on the wing covers which vary a good deal in size and shape, and sometimes form a cross of the ground color of the back; the sides and the thorax are dull red and the head black. The other species is the same length, about a quarter of an inch, but is somewhat stouter; the whole insect is dull red and polished and has twelve round black spots on the wing covers.

Both these beetles pass the winter in the adult stage and are ready to attack the asparagus shoots as soon as they appear above ground in the spring; these they gnaw and spoil for table use, and the Blue species deposits upon them its shiny black eggs which are attached by the tip to the plants. Later on the eggs of both species may be found upon the growing plants, and the larvæ soon appear. Those of the Blue beetle are dark olive gray grubs, which feed openly upon the foliage; the grubs of the 12-spotted are yellowish or somewhat orange in color, feeding at first upon the tender foliage, but boring into and devouring the pulp of the seed capsules as soon as they are large enough to attack. The life cycle of both kinds requires only six or seven weeks for its completion and we therefore find all through the season till sharp frosts come in the autumn, eggs, larvæ and beetles in great numbers at the same time; the pupal stage is passed beneath the surface of the ground.

The simplest and most efficient remedy is to let poultry have the run of the beds; they will devour both beetles and grubs and will not touch the asparagus.

Where this is not practicable, the young shoots should be dusted with fresh air-slaked lime when the morning dew is on the plants; this, of course, should be washed off before cooking. At the same time some of the shoots may be allowed to grow and attract the beetles which may then be killed with Paris green or arsenate of lead. If the plants have many eggs upon them, they should be cut off and burnt and others left to grow in their place.

After the cutting season is over the plants should from time to time be sprayed with one of the arsenical poisons, but when the seed capsules are formed this will be of no avail against the grubs of the 12-spotted species. To get rid of it, the seed bearing plants should be cut off and burnt. In early autumn it will be well to cut down and burn the whole of the plants.

The Asparagus Miner.—The stalks of asparagus are frequently attacked by insects, and in recent years have been reported considerably injured by the larva or maggot of a minute black fly to which the name asparagus miner has been given. The larva mines beneath the epidermis of the stalk, and when it has transformed to the puparium or "flaxseed" stage the thin outer skin becomes more or less ruptured and the presence of the insect is easily detected. It operates more abundantly near the base of the stalks and penetrates below the surface of the ground to a depth of 7 or 8 inches.

The larva is about one-fifth of an inch long and milk-white in color. Like other maggots, it is footless, large at the posterior extremity, and tapering toward the head.

The puparium is not unlike the flaxseed of the pernicious Hessian fly, with which it has been aptly compared. At a little distance, also, it suggests a Lecanium scale. This stage is remarkable because of its peculiar flattened and curved position, as seen from the side. It is red in color, and measures about 3.5 mm. in length and about 1 mm. in width. The egg has not been observed.

In its injurious occurrences this species appears to be limited to the eastern United States, from New England to Tennessee. With our present knowledge of the life economy of this species, two methods of control suggest themselves as of greatest value, and it may be that they will prove all that is necessary under ordinary conditions.

(1) In spring permit a few volunteer asparagus plants to grow as a trap crop, to lure the fly from the main crop or the cutting beds for the deposition of her eggs. After this has been accomplished the trap crop should be destroyed by pulling the infested plants and burning them with their contained puparia. The time to pull the plants will vary according to locality and somewhat according to season also. The second and third week in June would be about the right time in and near the District of Columbia. On Long Island this work should be done a week or two later. In the northernmost range of this insect—for example, in Massachusetts—the last week of June would be a suitable time. These plants must be destroyed before the end of the cutting season, otherwise they are apt to provide abundant rust infection.

(2) The second generation can be destroyed in like manner by pulling old infested asparagus stalks as soon as attack becomes manifest and promptly burning them also. If this work were carefully done over a considerable area, it would leave little necessity for other methods, since it would do away with these insects in the vicinity and leave few to be dealt with another season; unless, indeed, this insect has an alternate food plant. Thoroughness and the co-operation of neighboring asparagus growers are essential for success.—(Cir. 135, U. S. D. A. B. E.)

BEANS.

The Bean Weevil.—It is a very small beetle, one-tenth of an inch long, only half the size of the Pea-weevil, which in other respects it closely resembles. It is grayish brown in color, due to a coating of dense fine hair; the wing-covers are marked with a series of lines running lengthwise and have a mottled appearance. The beetle is oval in shape, the head is bent down and terminates in a short square beak; the end of the abdomen is not covered by the wings, and differs from that of the Pea-weevil in being destitute of the two oval black spots which are characteristic of the latter.

The eggs of the insect are laid upon the young bean pods; the grubs, as soon as they are hatched, bore through and enter the beans inside, several making their way into a single bean. Maturity is reached in the autumn, when the beetles emerge if the season is warm; otherwise they remain all winter in the ripened bean. If unmolested they will increase and multiply in the dry seeds and continue their work of destruction for a long time. It is therefore useless to hold over the seed for a year, as may be done to get rid of the Pea-weevil.

Whenever this insect is found to be present, the beans should be fumigated as soon as practicable after they are harvested. This is done by putting them in a barrel or tight bin and pouring on them one ounce of bisulphide of carbon for every 100 pounds, and then closing the receptacle tightly and leaving it for 48 hours. At the end of this time every insect will be dead. As the fumes of this substance are inflammable and explosive, it should not be used near any light or fire. Beans that have been injured by the insect should on no account be used as seed, as most of them will fail to germinate, or at any rate will produce only feeble plants.

The Bean Plant-Louse.—Windsor or Broad Beans and Horse-beans are not much grown in this country, though in some places they are found of value as an addition to ensilage. Some difficulty is experienced in obtaining satisfactory crops owing to their liability to attack by this black Aphis, which is a serious pest in Europe. At the time of flowering the colonies of this insect are to be found covering the tips of the plants so thickly that they look as if dusted with soot; if let alone they soon multiply enormously and greatly reduce the vitality of the plants.

The most successful plan is to cut off the tips of the affected plants and destroy the colonies of Aphis by burning or trampling under foot. This has the additional benefit of checking the growth and causing the pods to fully develop. Spraying with kerosene emulsion or strong soap-suds will also be effective.

Other Insects.—Beans, like other vegetables, are liable to be injured by Cutworms when the plants are small, and later on in the season by the Tarnished Plant-bug. Broad beans are also subject to attack by the Black Blister-beetle, which is one of the enemies of the potato plant, and sometimes appears in destructive numbers.

The Bean Leaf-Roller.—The bean leaf-roller is quite destructive to beans. The larvæ feed upon the leaves, eating holes in them or eating along the edges. Leaflets are folded over, to form a retreat.

The larva is about one and one-fifth inches in length, fusiform in shape, the body being thickest in the middle, with small neck and large head. The general color is yellowish, with a dorsal black strip, and two lateral orange stripes extending down the body.

The insect can be successfully treated. Use Paris green, in the proportion of one pound to 150 gallons of water, add to this one pound of quicklime, first made into a thin paste, to destroy the burning effects of Paris green on the foliage, or arsenate of lead 2 lbs. to 50 gallons of water. Apply with spray pump, keeping mixture well stirred.—(Bul. 45 Fla. Agr. Exp. Sta.)

BEETS AND SPINACH.

Blister Beetles.—Beets and spinach are liable to be attacked by many of the common garden pests that are general feeders, such as Cutworms which bite off the young plants close to the surface of the ground, Wire-worms and White-grubs which feed upon the roots, Flea-beetles, Leaf-hoppers, the Tarnished Plant-bug and Grasshoppers which affect the foliage. Descriptions of these insects and the methods of dealing with them will be found elsewhere. Mention may be made of a few other insects which occasionally attack these plants in injurious numbers.

Blister Beetles are long, narrow, soft-bodied insects which belong to the same family and possess the same blistering qualities as the Spanish-fly, which is used by druggists in the preparation of certain plasters. There are three species which may be distinguished by their color; the Black, the Gray and the Spotted; a fourth, the Striped, is occasionally to be found. Of these the Black is the most common and may often be seen feeding harmlessly on the flowers of the Golden-rod. At times these beetles appear in swarms and rapidly devour the foliage of beets, potatoes and a few other plants, and after inflicting a considerable amount of damage suddenly disappear. They may be controlled by spraying with Paris green, but this should not be resorted to unless the attack is serious, as their grubs have the very useful habit of feeding upon the eggs of grasshoppers and may therefore be included amongst the beneficent insects. A better remedy, which has been employed with success, consists in driving the beetles away from an infested field by a party of men or boys walking in a line across and waving branches from side to side. The beetles thus disturbed fly ahead, and by following them up may be cleared out entirely; once they are driven out of a field they seldom return. Spraying with Bordeaux mixture will keep them off the plants, and may be employed if necessary.

The Beet Leaf-Miner.—Blotches may often be seen on the leaves of beets and spinach, which are found on investigation to be caused by a minute maggot which feeds on the green tissue below the skin. The parent insect is a two-winged fly about a quarter of an inch in length, which deposits its eggs on the foliage of these plants; the maggots when hatched immediately burrow beneath the surface and cannot therefore be reached by any applications. The only method that seems at all available is to pick off and destroy the infested leaves, a laborious plan which can only be adopted where the plants are grown on a small scale. If the attack is serious it would be worth while to adopt this method in order to get rid of the trouble and guard against its repetition.

Caterpillars.—The foliage of beets and spinach is liable to be attacked by some caterpillars, but as a rule they are in small numbers, widely scattered over the plants and seldom inflict much damage. This does not apply to the extraordinary outbreaks on rare occasions of the Army-worm and the Variegated Cutworm, which devour every green thing that they come to, beets as well as everything else. Among the others referred to may be mentioned the Yellow Woolly-Bear, which is a hairy caterpillar, readily seen from its bright yellow color, and attaining to an inch and a quarter in length when fully grown. It turns into a beautiful snow-white moth, with a few black dots on its wings and rows of black and yellow spots on its body. When feeding they are conspicuous, and may be picked off by hand; but usually they are beneath the leaves when at rest. If very numerous, Paris Green may be employed. They are general feeders and do not confine themselves by any means to garden vegetables, but attack many kinds of weeds as well.

Leaf-Hoppers.—A number of species of leaf-hoppers feed on the leaves of the beet. All are small, rather slender, and all jump on the slightest provocation. They suck the sap from beneath the surface of the leaves, leaving a small dead spot to mark each puncture. This would ordinarily amount to little, but when the insects come in swarms, as is often the case, the aggregate amounts to a good deal. It is not possible to control these pests by spraying with poisons, as they pierce beneath the surface for their food supply. The contact insecticides will kill a certain proportion of them, but no spray yet devised is satisfactory unless used when the pests are small. They pass the winter in rubbish, under leaves, etc., therefore collect and burn all rubbish after cold weather sets in.

Grasshoppers.—When, from time to time, grasshoppers attack the beets, they should be killed by poisoned baits, provided of course, that such baits may be used without danger to stock or poultry. Criddle mixture, a mixture of arsenic, salt and horse-manure, is highly recommended by several who have tried it. Bran and arsenic, or paris green and bran, has the disadvantage that it is readily eaten by birds and poultry. For a further discussion of grasshoppers see Insects of Sweet-corn.

Beet Web-Worm.—From time to time we meet the beet web-worm, an insect that, on several occasions, has been very severe in its attacks. The eggs of the web-worm are laid on the leaves, and the larvæ that come from them attack the foliage, either spinning small webs among the young and tender shoots at the center of the plant, or else feeding on the underside of the larger leaves, either protected by a small web of silk or else exposed, with no protection whatever. The caterpillars are pale yellowish-green, or reddish-yellow in color dotted with small black points, each of which bears a hair. They are about three-fourths of an inch in length. The head is yellowish-brown marked with brown spots; the prothoracic shield is somewhat lighter in color. The backs of the first two segments each bear four black dots; segments three to eight each bear six black dots, arranged in two triangles. Segment nine has one larger median spot with two smaller lateral ones and segment ten has the anal shield, dirty yellow in color, marked with brown spots. The under side is marked somewhat similarly with dirty spots, each spot being bordered indistinctly with pale. The legs are pale with darker markings.

The pupa of this moth is buried in the soil. The larva spins a slender silken tube about three-quarters of an inch long, and in this tube the pupal stage is passed. In the early broods the pupal stage is of short duration, but the members of the last brood remain in the tubes over winter. There are several generations each year.

Spray with paris green on the first appearance of the larvæ, using lime as indicated in the directions for preparing insecticides. Use one pound of the poison to one hundred and seventy-five gallons of water. Plow the field after harvesting the beets, so as to expose the pupæ to the birds. In spraying, use a nozzle set at right angles to a short extension, so that it will be easy to spray upward from beneath.

CABBAGE AND CAULIFLOWER.

These plants are subject to a series of attacks by insects from their first appearance above ground to maturity. Cutworms destroy a great many seedlings and young plants when they are set out in the spring. Later on Plant-lice make their appearance, and cover the leaves with their colonies, sucking out the sap and causing the foliage to dry up and wither; they become excessively numerous towards the close of the season, and in addition to the injury they inflict, cause the plants to present a disgusting appearance. Throughout the summer the leaves are liable to be devoured by several caterpillars and in August and September by Grasshoppers, while the roots are frequently caused to rot by the Maggots of a small fly. Aphids and Cutworms and other general feeders are treated elsewhere; reference will therefore be only made here to such insects as are peculiar to the Cabbage and other Cruciferous plants.

White Cabbage Butterfly.—This insect, which came to us from Europe about fifty years ago, is now one of our commonest butterflies, and may be seen flitting about everywhere from early spring till cold weather sets in. It is one of the worst pests that the cabbage grower has to contend with unless measures are taken to prevent its ravages, and happily this is a matter of no great difficulty. The butterfly lays her eggs on the leaves of the food-plant; the caterpillars are velvety green and almost exactly the color of the leaves upon which they are feeding; when at rest they lie at length upon the midrib and are not easily seen. There are two broods in the year, the later being much the more numerous, and sometimes a third if the autumn should be fine and warm. The caterpillars riddle the outer leaves and then burrow into the heads, devouring the substance and spoiling the plant for table use by their excrement. Besides Cabbages and Cauliflowers they attack also mignonette, stocks and nasturtiums.

Pyrethrum insect powder is thoroughly effective. One pound should be mixed with four pounds of cheap flour and kept in an air-tight jar or canister for twenty-four hours so that the poison may be thoroughly incorporated with the flour. The plants infested by the caterpillars should then be dusted with the mixture which can be applied with a small bellows, or in a cheese-cloth bag tapped lightly with a slender rod. This powder will kill insects, but is perfectly harmless to human beings. Another method, which is more rapid in its effects upon the worms, is to dissolve two ounces of the Pyrethrum powder in three gallons of lukewarm water and spray at once. The liquid kills immediately all the caterpillars it reaches, while the dry powder often takes many hours to produce the same result. Paris green and other virulent poisons should never be applied to Cabbages and vegetables of any kind that are intended for table use.

Zebra Caterpillar.—There may often be found feeding upon Cabbage and some other garden plants of the same family, a handsome caterpillar about two inches long, when fully grown. It is velvety black on the back and has two bright yellow stripes along the sides, which are connected by a series of irregular yellow lines on a black ground-color; the head and feet are reddish. These strikingly contrasting colors render the caterpillar a conspicuous object on the green foliage that it feeds upon, and make it an easy task to pick them off by hand. There are two broods in the year, the moths, which are dull reddish-brown with white underwings, appearing in May and August. The young caterpillars when first hatched feed in colonies and devour the green substance of the leaves, thus producing white blotches on the foliage and rendering their presence easily noticeable. Should they be too numerous to be destroyed by hand picking, resort may be had to Pyrethrum powder applied as mentioned above, or to white hellebore which may be dusted on the leaves or sprinkled by mixing one ounce in two gallons of warm water, stirring from time to time to prevent the powder from settling at the bottom of the watering can.

Cabbage Plusia.—A pale green caterpillar, with whitish lines running lengthwise of the body, may sometimes be found devouring the leaves of cabbages, lettuce and other vegetables, feeding usually on the under side of the foliage. It is called a semi-looper from its raising the middle of the body when walking, owing to the absence of some of the usual prolegs. In the early part of the season they may be got rid of by dusting with a mixture of one pound of Paris green in twenty pounds of lime, applying the powder to the under side of the leaves. A liquid spray may also be used of the ordinary composition.

Diamond-Back Moth.—This is from time to time a serious pest, as its caterpillars appear in large numbers and devour the foliage of cabbages, turnips and other cruciferous plants. These worms are much smaller than those of the preceding species; are green in color and remarkably active when disturbed; they will then wriggle about in a violent manner and drop to the ground by a silken thread from the leaf on which they are feeding. As they devour all the green substance of the foliage the plant attacked soon withers and dies. There are usually two broods in the year, the first set of caterpillars appearing at the beginning of July, and the second towards the end of the summer; in favorable seasons there may even be a third. The winter is spent in the pupal stage, the lace-like cocoon enclosing the chrysalis being attached to the under side of the leaves. The moth is a beautiful little creature, dark or ashen gray in color, with a series of white marks on the forewings which form, when the wings are closed, a row of diamond-shaped markings down the middle of the back; from this characteristic the moth receives its name.

The remedy that seems most effective is spraying the underside of the leaves wherever attacked with kerosene emulsion, at the same time applying fertilizers, such as nitrate of soda, to induce a vigorous growth. As a preventive measure all remains of stalks and foliage, after the crop has been taken in, should be destroyed in order to get rid of the wintering chrysalis. Though the insect is an importation from Europe, it is largely kept in check by parasites and only occasionally becomes a serious pest.

Cabbage Maggot.—This is one of the most serious insects that growers of this vegetable have to contend with. Young plants, soon after being set out in the spring, are often found to have their roots infested with these maggots, their presence being indicated by the dying of the plants. They are white, footless larvæ, the offspring of slender two-winged flies, smaller than the ordinary house fly; the eggs are laid on the stems of the plants close to or just beneath the surface of the ground; when hatched, the maggots burrow down into the roots, where they tear the tissue with the hooks which take the place of their jaws, and live upon the sap; the breaking up of the cells of the plant causes a rot to set in and the entire destruction of the root soon follows. When full grown the maggots form their reddish brown puparia in the soil near by, and from these a second brood of flies soon emerges. Working under ground as they do, it is a difficult matter to apply any effective remedy; the only one that has proved useful is a decoction of pyrethrum insect powder (quarter of a pound to a gallon of water) or white hellebore of the same strength. The earth is drawn away from the root of an affected plant and half a tea-cupful is poured in; the soil is then replaced and hilled up around the stem.

Preventive measures are less troublesome and usually more effective. One of the best is the screening of newly set-out cabbages and cauliflowers with cheese-cloth. Light frames of slats are made 8 feet long, 2 wide and 2 high; over these is tacked cheese-cloth which should reach to the ground on all sides, and be prevented from blowing about by heaping a little earth on all edges. These frames cost very little and can be readily moved when required and stowed away for future use; they should be put on as soon as the plants are set out and left till they are well-grown. The frames not only prevent the flies from laying their eggs on the plants, but also keep off the other insects which are liable to attack them.

Tarred paper disks, three inches in diameter, with a slit from one side to the middle, are used to place around the stems of plants when they are set out, and prevent the flies from laying their eggs upon them. These are somewhat troublesome to make and put on and are not nearly so effective as the cheese-cloth screens.

Cabbage Aphis.—From mid-summer until fall, cabbages are subject to attack by plant lice. Of course the lice are present earlier in the season but in such small numbers that they escape detection. Both winged and wingless forms occur, all of them being covered with a coat of fine waxy powder, very much like the bloom on the leaves of the cabbage on which they rest. This waxy bloom, no doubt serves as a protection by helping to conceal the insect, but when we come to spray we find that it helps very effectually to repel the liquid. Lying, as they do, in closely packed colonies, which sometimes cover almost the entire underside of a leaf, one would expect to kill them with ease. One finds, however, on trying to do so, that most spray mixtures slide from them like water from a duck's back. Furthermore, it is very difficult to reach them when under the foliage. In order to overcome this last difficulty, we have used a short extension, about three and one-half feet long, with a Vermorel nozzle set at right angles to the extension. This makes it easy to reach the underside of the leaves and by simply turning the extension in the hand, one can spray downward on the head of the cabbage.

The best sprays for the lice that we have been able to find are tak-a-nap soap, used at the rate of one pound to four gallons of water, and Pyrethro-kerosene-emulsion made with whale-oil soap. This is diluted ten times. Both of these sprays killed apparently all the lice that were hit. The difficulty of hitting all the lice with a spray can be appreciated only by those who have made the attempt.—(Bul. 233, Mich. Agr. Exp. Sta.)

*The Harlequin Cabbage-Bug.**—The insects thus far mentioned as attacking cabbage do their injury by devouring the leaves. This one feeds in an entirely different manner, being provided with a beak with which it punctures and abstracts the sap. The effect of the puncture appears to be somewhat like that of the tarnished plant-bug. The leaves wither and turn brown as if scalded. It is very destructive at times, killing in this way the greater part of the plants in a field.

It is a glossy, flattish insect, about 3/8 inch long and nearly 1/4 inch in greatest width. The general color is black, and the markings are of an orange, or reddish yellow. The wings are ample, and ordinarily lie flat on the back, with the plain black tips overlapping. The young differ chiefly in lacking the wings. They feed at all times after hatching from the egg.

The calico-back, as it is sometimes called, places its relatively large eggs in two rows, side by side, on the leaves. They are somewhat barrel-shaped, each with a dark band about the upper end, and a faint line and dot near the attached extremity. These marks vary a great deal however, and may be wanting, while often extensive blotches appear. When the young hatch they push up a round lid-like piece at the free end of the egg.—(Bul. 114, Ky. Agr. Exp. Sta.)

The adult spends the winter among rubbish in gardens and fields, and comes out very early in the spring to feed on the first plants of the cabbage family to appear. Several broods develop during the season. Within the cabbage family, it seems to have no preferences. Among other plants, it is known to feed on peas, grapes, and even corn, at times.

Coal oil in emulsion is about the only thing that can be recommended for such insects, since it is necessary to kill them by means of a contact insecticide, except the use of the gasoline torch. Owing to the disposition of the insect to hide among the leaves where it cannot readily be reached with sprays, it is not easy to get rid of. One of the best remedies is the sowing of some trap crop before the regular sowing, then when the bugs have been drawn to it, plants and bugs can be destroyed with hot water, oil, or fire.

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* See page 411, for illustration

It is not consistently present in our fields. Some seasons it appears in scattered localities and occasions a good deal of complaint. Then it disappears and nothing is heard of it for a number of years. It seems not to endure very severe winter weather, being a southern insect, and this may account for its comings and goings.—(Bul. 114, Ky. Agr. Exp. Sta.)

Black Swallow-Tail Butterfly.—There may often be found feeding on the foliage of carrots and parsnips a handsome velvety green caterpillar ornamented with bands of yellow. This is the larva of one of our largest and most beautiful butterflies, black in color, ornamented with rows of bright yellow spots. The caterpillars do not feed in colonies and consequently are not often injurious, the amount of foliage consumed by an individual seldom affecting the vitality of a plant. Being conspicuous, they may, if sufficiently numerous to require repression, be picked off by hand and crushed under foot. They are kept in check, however, by a large parasitic fly, which lays an egg on a caterpillar from which hatches out a grub that feeds within the body of its host until the chrysalis is formed, and then completes its work of devouring all that remains, a fly with four clear membranous wings coming out instead of the butterfly.

Carrot Rust-Fly.—This is a more serious enemy to the plant than the preceding species. It is a comparatively recent importation from Europe, having been first observed in this country about twenty-five years ago. Its attack may first be noticed in spring when the leaves of young carrots turn reddish, and on examination the roots will be found covered with rusty blotches, hence the name of the insect. The parent of the mischief is a small two-winged fly, one-quarter of an inch long, with dark green body, head and legs pale yellow and the eyes red. From the eggs, which are laid on the stem below the surface of the ground, the young maggots make their way into the root, and tear the tissues in a similar manner to the cabbage maggot described above; the attack causes the rusty blotches to appear. The maggots of a later brood infest the full-grown roots and continue their work of destruction in the root-house during the winter. Celery and parsnips are also attacked.

Preventive measures seem to be the only remedies available. To deter the fly from laying her eggs, the rows of young carrots, when ready for thinning out, should be sprayed with kerosene emulsion, or dusted with sand or plaster in which coal-oil is mixed, half a pint being used to a pailful of the material. The application should be made weekly, and especially after hoeing, until about the middle of July.

In gardens where carrots are grown for table use and size is not an object, late sowing is found to be advantageous, the plants thus escaping the egg-laying of the fly. Repeated sowings a week or so apart, will secure the freedom of some of the crops from attack. The plants should not be grown two years running in the same piece of ground. Stored roots, if found affected in the winter, may be treated with carbon bisulphide, one ounce to 100 lbs. of roots, placed in pans on top of the pile, provided that they are in fairly air-tight bins. They should be left for 48 hours and then exposed to the air in order to get rid of the fumes, which are very inflammable; no light or fire should be anywhere near when this substance is being employed.

CELERY.

Celery, as a rule, is not much affected by injurious insects; those that do attack it are the same as the enemies of carrots and parsnips, to which reference is elsewhere made. The handsome caterpillars of the *Black Swallow-tail Butterfly* may often be found eating the foliage, but they are never very numerous and can easily be controlled by handpicking. A small caterpillar called the *Celery Leaf-Tyer* is sometimes abundant and injurious; it feeds for the most part at night; when young it eats small holes in the leaves which are hardly noticeable, but as it grows larger it becomes more voracious and consumes a considerable amount of foliage. When fully grown they roll up a leaf and tie its edges together with silk, forming thus a convenient case in which to pass the chrysalis stage. The moth is about three-fourths of an inch in expanse of wings, pale brown in color, with a reddish suffusion; the wings are marked with irregular cross lines of black and some circular spots. There are at least two broods in the year. The insect is sometimes known as the Greenhouse Leaf-tyer from its attacking a variety of hot-house plants; out-of-doors it by no means confines itself to celery, but may be found on a great variety of vegetables. As soon as the caterpillars are noticed the plants attacked should be sprayed with Paris green, applied to the under side of the leaves. In the greenhouse any infested leaves should be cut off and destroyed.

One of the most serious enemies of celery is the Rust-fly described among the insects affecting carrots. The maggots attack the thick part of the roots of young celery plants and prevent their proper growth; they also produce the characteristic rusty blotches on the stems and spoil them for table use.

Celery Aphis.—Occasionally celery is infested by one of the plant-lice or green-flies. The writer has never seen any serious injury by these insects, but in case they become troublesome, kerosene-emulsion should prove effective as should also tobacco water.

Little Negro-Bug.—This insect ordinarily seems to prefer weeds to celery, but on occasion, it has been known to overspread a celery field in late July, collecting in little clusters on the leaves, and playing sad havoc with the commercial fields. The outer leaves of the stalk suffer first, but later the inner, feathery ones that go to make the market head.

The cause of all this trouble is a small, shining black bug, very convex and quite broad comparatively, the length being a little less than one-eighth of an inch. The insect is said to rear only one generation each year. It is known to work on strawberry, raspberry, grape, wheat, some grasses, and a number of weeds, including red-root and ground-nut, beggar-tick, plantain, rag-weed and smart weed.

Mr. Davis recommends crude carbolic acid and water used at the rate of a teaspoonful to two gallons of water and sprinkled over the plants or else crude carbolic and air-slaked lime used at the rate of a teaspoonful of the acid to a bushel of lime, and dusted over the plants. The emulsion of carbolic acid diluted so that the same amount of the acid is found in two gallons of water, will make a more even preparation and one would expect less danger from burning the plants than with the plain mixture. The experimenter has never had an opportunity to try this, however. Mr. Davis found that hot water killed the bugs when used at 155 degrees Fah. and that the plants were killed at 175 degrees. On a small scale, this can be applied with a sprinkler if care be taken to test the water with a thermometer carefully and at short intervals.

The long list of weeds which serve as food-plants for this little nuisance, shows plainly that the removal of weeds from the vicinity of the celery fields will be the most effective preventive measure at our command. Clean culture is, after all, a measure which pays well.

CUCUMBER AND MELON.

Cucumber Beetles—the Striped and the Spotted.—The former of these insects may be found all through the season on cucumbers, melons, squashes and pumpkins from the time that the plants are first set out till the frost destroys the foliage in the autumn. The beetles hibernate in the adult stage and are ready to attack the seedling plants as soon as they appear above the soil; oftentimes they are sufficiently numerous to kill the tender plant by eating the leaves and gnawing the stem; later on they may be found in the flowers, where, however, they seem to feed on the nectar and not to do much harm. The beetle is less than half an inch in length, oval in shape, yellow in color, with a black head and three black stripes down the back. The larvæ are slender white grubs which feed upon the roots of the plants and sometimes burrow up into the stem, continuing their injuries for about a month, when they change to the pupal stage and later on come out as a second brood of the beetles. The latter are very lively insects, flying quickly from plant to plant when disturbed; sometimes when their usual food is not available they attack the young pods of peas and beans, and may be found on a variety of other plants.

The Spotted Cucumber beetle is larger than the Striped, and less oval, broadening considerably towards the posterior end of the body; its color is yellowish green, with a black head and three rows of four black spots, making twelve in all, on the wing covers. It is a more southern insect than the Striped beetle, and in many parts of the United States it does serious injury to the roots of corn. It is a much more general feeder, attacking a great variety of plants; its life history is somewhat similar to the preceding, but it seems to feed mostly upon the pollen of blossoms in the beetle stage, the grubs being the chief cause of injury by their attacks upon roots and stems.

The treatment for both insects is chiefly preventive. Young cucumber and melon plants should be protected as soon as they are set out with the cheese-cloth screens described as a protection against the Flea-beetles, or by smaller screens made with two flexible sticks crossed at right angles and with their ends securely fixed in the ground, and then covered with a piece of cheese-cloth, which can be kept from being blown about by heaping a little earth on the edges. These screens may be safely removed when the plants have grown too big to be covered by them. Another plan is to grow a few squash plants earlier than the others so as to attract the beetles to them, and then treat them with Paris green, one pound mixed with 50 lbs. of lime or plaster; this may be dusted over the plant when the beetles congregate upon it. In the autumn all the refuse of the vines should be gathered up and either burned or buried in a compost heap, so as to kill the hibernating beetles. Spraying the young plants with poisoned Bordeaux mixture has also been found effective.

The Squash-Bug.—The bugs are much larger insects than the beetles described above, being nearly three-quarters of an inch in length, of a dirty blackish color above and speckled creamy beneath; they have the usual repulsive odor common to the stink-bugs, to which family they belong. Late in autumn the bugs may be found in all sorts of places, crawling about in search of winter quarters, and should then be crushed under foot. In the spring they come out, and begin their injurious work of sucking out the juices of young cucurbitaceous plants. The eggs, which are metallic in color, are laid in batches on the under side of leaves near the base of the plant; from them soon hatch out the young bugs, but not all at once, so that we may find nymphs of all sizes on the under side of the same leaf. They not only injure the foliage by sucking out its juices, but also poison it as well, causing a speedy wilting of the leaves they attack. If any withering leaves are observed they should at once be inspected, and if a colony is found at work it can soon be exterminated by crushing under foot.

These bugs are difficult to get rid of, as the usual remedies for sucking insects, kerosene emulsion, for instance, have but little effect upon them, except when applied to the colonies of young nymphs. The methods recommended above for Cucumber beetles are also the best remedies for these disagreeable insects. In the early part of the season the parent bugs may be trapped by laying pieces of shingle or board near the plants; the bugs will be found taking shelter under them in the morning and can easily be destroyed.

Flea Beetles, described above, are often very injurious to young cucumber and melon plants, and also a species of Aphis. Occasionally the fruit is attacked when green by small caterpillars, one called the Pickle-worm, and another the Melon caterpillar; both turn into beautiful little moths. In the South they are regularly injurious year after year. Should they become numerous at any time they could be easily controlled by the use of arsenical poisons.

The Pickle Worm.—Injurious to the fruit of cantaloupe, squash, cucumber, and other cucurbits. Holes are eaten into the rind or quite to the interior, causing the decay of the fruit. The insect appears after the middle of June, and early crops hence escape their ravages.

Eggs are probably deposited, as a rule, on the fruit, blossoms or foliage, and the young larvæ soon begin to feed. The life cycle requires about twenty-seven days, and several broods occur each season. The winter is past in the pupa state in the dead cucurbit leaves, and trash in and around the field. About seven months of the life of the insect seems to be passed in the pupa state.

The most hopeful method of protecting cantaloupes from this insect, that we have discovered, is in the use of squash plants as a trap crop. A decided preference seems to be shown for the bloom, vines and fruit of squash, which should be planted in and around cantaloupe fields, and the larvæ carefully collected and destroyed. Arsenites and repellants have not thus far proven to be effective.

Melon-Louse on Cucumber.—At all times after cucumbers commence to "run" they are subject to attack by a plant-louse. The insect is blackish-green in color and both winged and wingless forms occur. They multiply so rapidly as almost to cover the under sides of the leaves in a short time. Ordinarily in large fields, the attack commences in certain small, well-defined areas, from which the trouble spreads rapidly in ever widening circles rendered conspicuous by the curled and discolored leaves. The source of the pests was for some time a mystery, but Mr. Theodore Pergande, of our National Bureau of Entomology, throws a great deal of light on the subject when he explains that the same insect feeds also on cotton, orange, melons, strawberry as well as on a long list of our common weeds. In the light of this information, it is easy to see how the pest is kept alive until opportunity to attack melons and cucumbers offers itself.

The fact that the pests work almost entirely on the undersides of the leaves, where it is difficult to apply sprays, makes them very serious pests to combat. The writer has made an effort to select a spray that will kill the greatest number of those hit, trusting to the operator to hit as many as possible and to repeat the application when necessary. Others have found it practical to place a low tent over the plants, and to fumigate with burning tobacco stems and other agents. Such fumigation has given partial success, but seemingly is little, if at all, superior to the sprays. The cost of fumigation is unquestionably greater. The spray that gave the best results with us was whale-oil soap kerosene-emulsion, with Pyrethrum added. (See directions for preparing insecticides.) This was diluted ten times. We succeeded in killing about 99 per cent of the lice, in one trial, doubtless all that were hit. In order to apply this spray with sufficient thoroughness, a knap-sack pump was used. This was fitted with a short extension, about three feet long with a Vermorel nozzle set at right angles to the extension, making it easy to apply the spray sidewise and upward from beneath.

As stated, the lice usually start from one or two vines in a field. Careful watching will reveal these centers of infestation and prompt treatment should check their spread in the beginning. Of course it will be necessary to repeat the spray as often as the lice appear. As in the case of the lice on cherry, the difficulty lies in reaching the lice and not in making a spray that will prove effective.—(Bul. 45, Ga. Agr. Exp. Sta.; Bul. 233, Mich. Agr. Exp. Sta.)

INSECTS AFFECTING THE HOP.

Hop Merchant.—The spiny caterpillar of the hop-merchant is known to all hop growers. After a time, these caterpillars change to the naked pupæ which are marked with golden or silver spots. From these pupæ come the adults, very pretty butterflies of a general brownish color, marked with darker brown and slate. On the underside of each hind-wing is a silver mark, shaped like a comma, from which the insect takes its Latin name. The eggs are laid in strings on the leaves. Besides hops, the caterpillars feed on elm and nettle.

The only remedies are hand picking and spraying with arsenical poisons early in the season. After the hops form, no sprays should be applied because of danger from poisoning.

The Violet-Tip.—The violet-tip closely resembles the hop-merchant. It is, however, larger and the greys on the wings are apt to take on a more purplish tint. Each hind-wing is marked with a silver spot something like an interrogation mark. The larvæ feed on nettle, elm and blackberry as well as on the hop. The treatment is the same as that for the hop-merchant.

Hop-Louse.—Such a fragile creature as an aphid can hardly hope to pass the winter successfully on such a plant as the hop which is spread on the ground during the cold season. For this reason a curious habit has been developed. Late in the season, winged sexual forms are developed from the non-sexual form of the lice that have been feeding on the hop all summer, and these sexual forms lay their eggs on the plum trees, where the eggs are in good high situations, safe for the winter except from birds and other enemies. In the spring, wingless forms are produced at first, and from these, winged females which migrate to the hop to become the parents of the myriads of lice which later appear.

The lesson to be learned from this life-history is very easy to see. Avoid having plum trees, either cultivated or wild, near the hop yards. If it is impossible to do this, then spray the plums with kerosene-emulsion, or tobacco-water just as soon as the eggs hatch, and spray with extreme care so as to hit as many of the lice as possible, before they migrate to the hops. It will be necessary, in many cases, to spray the hops themselves, especially the vines on which the lice first appear, and which serve as centers of infection for the rest of the field.—(Bul. 233, Mich. Agr. Exp. Sta.)

Onion Thrips.—Tiniest of all the insects mentioned in this paper, is the onion thrips. A little larger than a printed period and very active, it is so small and quick in its movements, that it is usually overlooked. The injury is brought about by the great numbers that collect on the plants. On the onion, the thrips prefer the axillary portion of the plant, where two leaves join. They scrape the soft material off the leaves, giving them a grey or hoary

HIGH POWER SPRAYING OUTFIT IN USE IN TREATING ROADSIDE TREES. [illegible]

appearance, sometimes noticeable at quite a distance. The leaves or tops decay if the weather turns wet and the keeping qualities of the bulbs are impaired.

The immature insects are usually more abundant than the adults, they are about one-twenty-fourth of an inch in size, and yellowish-green in color. The body is long and slender, with six legs and six jointed antennæ. The feet, like those of all true thrips are destitute of claws. The general color is dirty yellow with dusky markings. The antennæ are seven-jointed in the adult. The extremely narrow wings are fringed with long hairs giving them a feathery appearance. The time required for each generation is said to be about six days in the South. Here in Michigan, more time will, no doubt, be required; at any rate, a number of broods are developed each year.

Thrips feed by scraping minute particles off from the soft parts of the plants, but as far as their control is concerned, they may be classed with the sucking insects, and we must resort to contact insecticides to kill them. Kerosene-emulsion, used at the rate of one part of the emulsion to ten of water will kill them. Tobacco water should also prove effective. Drenchings of cold water are said to be useful when practical, for thrips thrive best in a dry, warm atmosphere.—(B. 233, Mich. E. S.)

ONION.

Onion Maggot.—It is very similar in mode of attack and life-history to the Cabbage Maggot already described; it is unnecessary, therefore, to repeat these particulars. It is often extremely destructive, and has almost driven market gardeners to despair. The preventive measures referred to above are hardly suitable for a plant whose style of growth is so different from that of a cabbage, and few persons would take the trouble to protect onion beds with cheese-cloth screens, nor could tarred paper disks be employed. There is, however, a simple method of protection which has been found effective: as soon as the tiny shoots of the onions begin to appear above the soil, the rows should be treated with a whitewash made of lime and water, and thick enough to form a thin crust over the surface. The effect of this is to close up all crevices and openings in which the parent fly would lay her eggs, and prevent the maggots which may hatch for any eggs laid above ground from reaching the roots beneath. The young plants penetrate through the thin crust of lime without difficulty.

Later on, when hoeing, any plant that is not growing satisfactorily should be cut out and crushed underfoot so as to destroy the maggots. Furthermore, onions should not be grown a second time on, or close to, a bed which has been infested with these insects. Pyrethrum insect powder or white hellebore may be applied in the same manner as recommended for the cabbage maggot. Many other substances, such as salt, plaster, Paris green, etc., have been tried without any satisfactory results. When taking up the onions in the fall any bulbs infested by maggots should be carefully destroyed.

PARSNIP.

Parsnip Webworm.—When parsnips are left in the ground all winter and allowed to grow up for seed-bearing purposes during the following season, they are very liable to be attacked by this insect. Towards the end of June, when the stems are tall and bear fine umbels of flowers, it is often found that the bloom is disfigured with webs which draw the whole into an untidy mass, and on examination a colony of small caterpillars will be found at work within. When they have finished consuming the flower, they burrow into the stem and feed upon the soft inner lining; here they change to the chrysalis stage during the latter part of July, and are often so numerous that the hollow stems will be found packed with larvæ or pupæ. The caterpillars are of a dirty green color above and yellowish on the sides and beneath; most of the segments are furnished with shining black warts, each of which terminates in a fine bristle. The moths come out about the first of August and hibernate in any shelter that they can obtain, often coming into houses for the purpose; they are dusky gray in color, with no conspicuous markings, and with the body much flattened; the expanse of the wings is less than an inch, and the length of the body under half an inch. The insect is an European species.

These caterpillars may be found in abundance working in a similar manner on celery plants that have grown up for seed and on wild carrot and other kindred umbelliferous plants. In the garden they should be treated with Paris green as soon as they are noticed; if the umbels are drawn into a web, they should be cut off and burnt, and if the stalks are perforated the same operation should be performed on them. Wild carrots and parsnips should be cut down wherever they may be found in neighboring fields or waste places. Parsnips are also attacked by the insects already mentioned in connection with carrots and celery.

PEAS.

Pea-Weevil.—The life-history of this insect resembles in many respects that of the Bean-weevil, already described. The beetle is about one-fifth of an inch in length, brownish-gray in color, with two conspicuous oval black spots on the end of the abdomen which is not concealed by the wing-covers. The head is bent under the front of the body and ends in a square-cut beak. When peas are in blossom these little beetles may be found upon them, waiting for the young pod to be disclosed; on it the minute eggs are laid, and the grubs, as soon as hatched, bore through and enter the small green peas, one beetle only infesting a single pea. Here the grub remains, feeding upon the substance of the pea, passing through the pupal stage, and only attaining maturity when the peas are ripe and ready for harvesting. Most of the beetles remain inside the peas until they are sown the following spring, but some emerge when the peas become ripe, and remain in the field or in the barn all winter. Unlike the Bean-weevils, this species does not increase and multiply in the stored peas, but will die if they are kept over for another year.

The pea crops should be harvested early, a little on the green side, so that the pods will not shell out before removal from the field; threshing should be done as soon as possible, and all refuse from the machine should be swept up and burnt. If any weevils are noticed in the peas, the crop should be put into bins or barrels and fumigated with carbon bisulphide in the manner recommended for the Bean-weevil. Peas that contain weevils, even though they are dead, should not be sown, as the plants grown from them will be stunted owing to the lack of food material in the pea; a considerable proportion would probably not grow at all, owing to the germ having been devoured by the beetle. The remains of the crop, not taken from the field, should be raked up and burnt. If every pea-grower would adopt these methods we should soon be rid of the pest as the beetle does not attack any other plant.

Pea Moth.—The parent moth is small, less than half an inch in expanse of wings, and of a dull, slaty-gray color. It lays its eggs on the growing pods of peas; the caterpillars soon hatch out and bore their way into the pod, where they feed upon the young peas, consuming many of them and filling the space with a mass of excrement. When full grown the worms leave the pods and form their small oval cocoons below the surface of the ground.

Where there is reason to expect an attack, the pea vines should be sprayed as soon as blossoming is over with a liquid wash of one pound of soap in twenty-five gallons of water in which has been thoroughly mixed four ounces of Paris green; the spraying should be repeated a couple of times at intervals of a week or ten days. The object is to poison the young caterpillars when they are eating their way through the pod.

Sowing early varieties as early as possible in the season has been found useful, the pods being too far advanced to be injured when the worms appear. Very late sowing is also recommended in order that the blossoming may not take place till after the moths have ceased egg-laying.

An important point is to plow or dig deeply in the fall any piece of land where infested peas have been grown in order to bury the cocoons and prevent the moths coming out in the spring. All unripe pods should be burnt, as they may contain worms, and peas should not be grown again upon or near the same piece of ground the next season.

Pea Aphis.—This large green plant-louse has during recent years become extremely destructive to the vines of peas. In some parts, where large acreages were devoted to this crop for canning purposes, the annual loss was estimated at many millions of dollars, three-fourths of the crop being in some instances destroyed. The usual remedies for plant-lice have already been referred to under "Aphis," but they are of little value when contending with an attack on a very large scale. A method that has been found effective is to sow the peas with drills and wide enough apart for a cultivator to work between the rows, instead of the usual broadcast plan. As soon as the plants are seen to be infested boys are employed to brush the insects off, and they are followed at once by the cultivator, which buries the lice and prevents their getting back on the vines. The operation has to be repeated a few times, but the results have proved entirely satisfactory and warrant the labor and expense.

POTATO.

Colorado Potato Beetle.—Is so familiar to everyone that it is hardly necessary to give any description of the destructive creature. The adult beetles come out of their winter hiding places about the end of May and feed at once upon the earliest appearing potato plants; soon after this the females lay their bright orange colored eggs on the under side of the leaves in batches of various numbers up to fifty or more. The grubs hatch out in about a week and set to work to devour the foliage; their dark orange color renders them somewhat conspicuous, so that an attack can hardly fail to be noticed. When fully grown the insect changes to the pupal stage in a cell a few inches below the surface of the ground. A period of about eight weeks is required to complete a life cycle, and then a second brood of beetles appears, lays its eggs and starts new colonies of grubs; the third brood comes out in September and may be observed crawling or flying about in search of winter quarters. The broods are by no means distinct, as all the grubs do not mature at the same time, consequently the insect may usually be found in all its stages at any time during the summer.

The well-known and long-tried remedies are Paris green or arsenate of lead combined with Bordeaux mixture, the latter ingredient assisting in warding off the attacks of fungous diseases and also in destroying Flea-beetles, when they are present, as they commonly are. Spraying should be done early in June as soon as any grubs are to be seen, again a month later, and three times, at intervals of a fortnight, between the end of July and the first of September.

Three-Lined Potato Beetle.—Looks very like the Striped Cucumber beetle, but is larger and of a darker yellow color. Before the coming of the Colorado beetle this was the chief insect enemy of the potato, but now, though common, it is not usually particularly destructive; its life-history is much the same, the adult beetle coming out in the spring and laying her eggs on the under side of the leaves of the young plants; these are yellow in color and are laid along the midrib of the leaf. The larvæ have the extraordinary habit of piling their excrement on top of their backs, possibly as a protection against their enemies, and thus present a disgusting appearance. The grubs appear in June and go through their transformation in time for another brood to come forth in August; the beetles from this later brood do not emerge till the following spring. When this insect is at all abundant, it can be easily controlled by the application of Paris green; the measures everywhere taken to check the Colorado beetle have no doubt prevented this species also from becoming numerous.

Potato Flea-Beetle.—Is one of the most serious pests of the potato plant. The tiny creature—it is less than one-twentieth of an inch long—eats small holes all over the surface of the leaves and causes much injury in this way; but a worse result is that the spores of the fungous diseases called "Blight" find a suitable place in these holes for germination and the complete destruction of the leaf soon follows. Flea-beetles as a class have already been referred to; it is unnecessary, therefore, to do more than state that spraying with Bordeaux mixture is a satisfactory remedy for both the insect and the blight.

Blister Beetles are often reported as appearing suddenly in great swarms in the potato fields and greedily devouring the foliage. An account of them has already been given under insects attacking Beets and Spinach.

Potato Stalk-Borer is an occasional cause of injury to the plant in this country, but in some of the States to the west and south it is considered almost as great a pest as the Colorado beetle. As the name indicates, the attack is made by boring the stalk; this is done by the grubs, which are whitish in color and without legs. The small beetles, about a quarter of an inch long, are ashen-gray in color and belong to the family of weevils or snout beetles, having the head developed into a long beak; the base of the wing-covers is marked with three distinct black spots, which readily distinguish it from similar species. About the month of June the parent makes a hole in the stalk of the potato with its snout and deposits an egg and repeats the operation a number of times. The grubs which hatch from them burrow up and down in the stalks, devouring the interior, and when full-grown, about the beginning of September, form their cocoons inside the stalk near the base of the plant; the beetles emerge later on, but remain in this retreat all winter.

No application of poison is of any avail, as the grubs are out of reach in the stalk, but much may be done to exterminate the insect by cleaning up and burning all the remains of the plants after the potatoes are dug in the fall; this is advisable also in order to destroy the germs of fungous diseases.

RADISH.

Radishes are very liable to attack and serious injury when they first come up in the seed beds by the minute Flea-beetles described among the insects that are general feeders; cheese-cloth screens are found to be the best protection. The Radish-maggot is the same or a very closely allied species to that which attacks the roots of cabbages, and may be treated in much the same way; protection with cheese-cloth is by far the simplest and entirely effective method of securing perfect radishes in the spring.

INSECTS AFFECTING RHUBARB.

Rhubarb Snout-Beetle.—Rhubarb is usually free from insect pests, there is, however, a long, slender snout-beetle, which is to be found early in the spring and late in the fall, resting on the plants. It is dark grey in color and covered with a rust-colored powder that rubs off easily. This beetle is the parent of the white, grub-like borer that tunnels in the leaf and flowerstalks, and the eggs of which are laid in small cavities cut in the tissue of the plant. It is said that the practice of removing the old leaves regularly will take care of the pests, as the borers will in this way be destroyed just as fast as they come, and the new stalks will be found to be free after a little time. The insect also feeds on dock, and for this reason, it is well to destroy all the docks in the vicinity of rhubarb plants.

INSECTS AFFECTING THE SQUASH.

Squash-Vine Borer.—It often happens that squash-vines suddenly wilt, just as they are getting a nice start. This may be due to one of several causes, sometimes a bacterial disease is the cause and sometimes one of the fungous diseases; often, however, one finds on examination that there is a grublike borer in the hollow stem, and that a tunnel has been gnawed down into the roots. Here the borer dwells, sometimes above and at others below the level of the soil. When full-grown, this grub leaves the tunnel and pupates near by in the soil. In the following spring the adult appears. The adult is a very pretty insect belonging to the family of moths known as clear-wings, because the wings of many of its members are partially transparent. The moth of the squash-borer measures about one and one-fourth inches across the extended wings, from tip to tip, the front wings being green and the hind-wings clear. The body is reddish except for the basal part which is green like the front-wings. The hind-legs each bear a fringe of long hairs. The species is said to be single brooded in this part of the country. Further south it is double-brooded.

The remedies for this pest are three in number. The results are most satisfactory when all three are used together.

Trap Plants.—Fortunately the borer works in summer-squash as well as in the winter varieties, the summer-squash planted between the rows of winter-squash, will attract the majority of the borers. Later, when they have all become settled in their burrows, the early varieties may be pulled up and burned leaving the later ones free from the borers. Many times it is possible to cut out the larvæ by making a longitudinal slit in the vine.

Last, but perhaps best of all, the vines may be induced to put out roots at short intervals by placing a little soil over the joints, thus supplying plenty of food to the vine even after the tap-root has been destroyed. If the plant escapes until it has commenced to run well, it is easy to induce roots to grow by pulling a couple of hoefuls of soil over some of the joints.

Cucumber-beetle (see Insects of the Cucumber).

Squash-bug (see Insects Affecting the Cucumber).

TOMATO AND TOBACCO.

These two plants may be associated together, as the same insects are liable to attack both. Cutworms early in the season are very destructive to the young plants, but may be warded off by the use of the poisoned bran-mash. The leaves are liable to be attacked by the Flea-beetles, the Tarnished Plant-bug and Grasshoppers. The most conspicuous enemy of both plants is

Five-Spotted Hawk Moth, or Tomato Worm.—This is a large caterpillar, attaining to a length of nearly four inches when fully grown and correspondingly thick; it has a series of oblique pale lines along the sides and a prominent tail; in color there are three varieties, pale green, dark green and almost black. They are very voracious feeders, and soon strip the foliage from a plant; but being so conspicuous they can be readily got rid of by hand picking. When growth is completed, the caterpillars burrow into the earth and form a cell in which they transform to a dark brown chrysalis, which has attached to the head and underside of the thorax a projection resembling the handle of a jug and containing the enormously long sucking tube with which the moth is provided. Usually it remains buried in the ground until spring, but occasionally some of the moths come out in the autumn if the weather should be warm. They are large, handsome, swiftly flying creatures, ashen-gray in color with a variety of paler and darker lines and markings; the abdomen is ornamented with five large orange spots on each side which give the insect a very characteristic appearance. These Tomato worms have often been supposed to be poisonous, and many marvellous tales have been told of their deadly stings and bites; they are, however, quite incapable of either stinging or biting, and may be handled without the least danger.

Corn Ear-Worm.—This, which has been described above, frequently attacks green tomatoes before they are fully grown and bores large holes which utterly destroy the fruit. It also feeds on tobacco, eating into the unripe seed capsules and devouring the contents. In the case of tomatoes the only plan seems to be to cut off and destroy all the infested green fruit. Where tobacco is extensively grown, if there should be an annual attack of these caterpillars, it would be advisable to grow a strip of corn as a trap-crop along the sides of the field; the moths would lay their eggs on the young ears of corn in preference to the tobacco plant, and these could be gathered and burnt or fed to pigs before the worms attain to maturity.

TURNIPS.

Turnips are attacked by several of the insects already described as enemies of the cabbage, viz., the Zebra Caterpillar, the Diamond-back Moth, the Cabbage Maggot, and the same species of Plant-louse (Aphis). The last mentioned insect has been more complained of recently by turnip growers than any other pest; its ravages in late summer and autumn of 1908 were widespread over Canada, due to the prolonged dry, warm weather which was favorable to their increase, and in many cases whole fields were rendered worthless. The usual remedies, kerosene emulsion and strong soapsuds, were found effective when applied in time; but in most cases the attack was not noticed till the damage was beyond repair. Much may be accomplished by keeping a sharp look-out for the colonies of plant-lice when hoeing is being done; an affected plant should be at once cut out and the lice crushed under foot; early measures of this kind will prevent a serious infestation later on.

Turnip Flea-Beetle.—Differs from our other species in having a wavy yellowish stripe down each side of the wing covers, but its habits are much the same as those of the rest of the family. Its attacks on the young plants when they first come up are often very serious and prevent the growth of a large proportion of the crop, necessitating a resowing. As the first brood of beetles disappears toward the end of June it has been found that turnips sown during the third week of that month escape attack, and produce as good a crop as those sown earlier. When the beetles are observed to be attacking the young plants they may be got rid of by dusting with Paris green and land plaster, one pound of the poison to twenty of the plaster; this should be done when the plants are moist with dew in the early morning. A condition of the soil which induces rapid and vigorous growth is of great importance, as it enables the young plants to get beyond the danger point before much injury has been sustained.

INSECTS AFFECTING THE SWEET POTATO.

The Sweet Potato Flea-Beetle.—This is a small bronze or brassy-brown beetle about 1/16 of an inch long. The eggs have not been observed but the larva and pupa have been found on birdweed roots. The plants should be dipped in arsenate of lead, one pound to six of water, before being set.

The Two-Striped Sweet Potato Beetle.—This is one of the Gold-Bugs or Tortoise-Beetles. Its color is rather dull brownish-yellow with only a faint golden lustre while on each wing cover there are two black stripes; the insect is ¼ inch long. The larva is dirty yellowish-white.

The Golden Tortoise-Beetle.—This species is a uniform golden yellow and measures ¼ inch in length. The larva is dark brown and carries its excrement about on an anal fork.

The Black-Legged Tortoise Beetle.—This beetle is 5/16 of an inch in length, golden but not so brilliant as the foregoing and has three black spots on the wing covers and black legs. The larva is pale yellow.

The measure used against flea-beetles, dipping, will prove sufficient to control this group of beetles ordinarily, but should the larva become numerous later, spraying with arsenate of lead, 2 lbs. to 50 gallons of water, should be effective.—(N. J. Agr. Exp. Sta. Bul. 229.)

BULLETINS USED ON VEGETABLE INSECTS.

Bul. 171, Ontario Dept. of Agr., also Cir. 135, U. S. D. A. B. E.; Bul. 233, Mich. Agr. Exp. Sta.; Bul. 114, Ky. Agr. Exp. Sta.; Bul. 2, Va. Truck Exp. Sta.; Bul. 45, Ga. Agr. Exp. Sta.; Bul. 45, Fla. Agr. Exp. Sta.

INSECTS AFFECTING GRAIN.

[The pests of wheat and corn include all the principal injurious insects that attack barley, rye, oats and all other grains. For such injuries refer to corn and wheat insects.]

INSECT ENEMIES OF CORN.

The insect enemies of Indian Corn are legion, and may be found attacking every part of the plant, root and stem, leaves and ears, the tassel and silk, and the ripe harvested corn; about 350 different species are recorded from North America. It is unnecessary to describe more than a few species which are always with us and against which constant warfare has to be waged.

Attacking the roots we find White-grubs and Wire-worms very destructive, especially where corn is planted on old pasture land broken up a year or two before. These insects have already been described. Another serious enemy is the Corn Root-aphis, which is attended by its ant protectors; it is especially injurious to the plants when young. The winged forms migrate to various common weeds such as plantain, pigweed, etc., showing the importance of keeping fields and gardens free from these places of refuge.

As soon as the tender blades of corn appear above the soil they are liable to be cut off by those nocturnal marauders, the Cutworms, which can be circumvented by the use of the poisoned bran-mash. The grubs of the 12-spotted Cucumber beetle often infest the roots of corn when the plants are young, and a great deal of loss is occasioned by them. Later on, as the plants grow bigger, they may be attacked by Grasshoppers and seriously injured.

*The Corn Root Aphis.**—The corn root aphis is by far the most injurious of the six species of aphids that infest corn. It sucks the sap from the roots, impoverishing the plants, and doing the most injury when the plants are small. The welfare of the root lice depends largely on the care bestowed on them by ants, several species of which attend them and protect the eggs over winter, besides caring for the lice during the growing season.

The best results seem to follow rotation, together with late fall plowing in order to break up the nests of the ants. The aphids feed on other plants and like especially smart-weed, pigeon-grass, and purslane. Heavy applications of fertilizer are said to help the plants to recover from the early attacks. The aphids spread quite freely, but are worse when corn follows corn than when corn follows something else. Keep out the weeds above mentioned.

Southern Corn Root-Worms.—Two corn root-worms occur. One of them is the Southern Corn Root-Worm, which is a first-class corn pest, in parts of some of the states south of us. As it has not, thus far, been guilty of depredations in Michigan, we will merely refer to Dr. Forbes' full account of the creature, and state that it is said to bore, when in the larval stage, into the stalk beneath the surface of the ground, sometimes killing the plant outright, but oftener retarding it so that it is still green when frost comes.

Northern Corn Root-Worm.—Tunnels in the roots themselves, and is, when abundant, said to be even more serious. These root-worms are small grubs, white in color, and about four-tenths of an inch in length in the case of the Northern species, and about fifty-six-one-hundredths in the case of the Southern species.—(Mich. Bul. 258.)

Wire-Worm.—Low ground and more especially mucky ground, is apt to be infested with wire-worms. These are slender, yellow, little creatures, cylindrical in form, and in size varying from half

* For illustrations, see pages 213 and 375.

an inch to more than an inch in length. All have hard, polished skins amounting almost to shells, and six short legs just behind the flattened heads, besides a sucker-like false-foot on the last segment. Wire-worms usually feed on the roots of grains, corn and other grasses, though they will not refuse potatoes when occasion offers. There are many species to be found, and while one may prefer corn, another wheat, and so on, they may all be considered as injurious, except those found in rotting wood, and treated together. The adults are the common snapping-beetles or click-beetles, the little fellows that jump up into the air with a click, when placed on their backs. These beetles lay the eggs from which the wire-worms hatch, and the wire-worms in turn become click-beetles after passing through a chrysalis stage in their little earthen cells in the soil. It is probable that two years are required by the larvæ to attain maturity. The winter is passed in little cells in the soil in some cases, while in others the adult beetles emerge in the fall and hibernate.

Wire-worms are primarily insects of grassland and the fact that they require two or three years to develop helps to explain why it is that they are often worse the second year after grass than they are the first, most of them being full-grown at that time.

In corn, the most noticeable injury is to the seed after planting, though the larvæ also feed on the roots after the corn is up. A long series of experiments by Professors Comstock and Slingerland of Cornell University, failed to show any practicable method of treating the seed so as to prevent injury by wire-worms. They did show, however, that late fall plowing killed many of the pupæ and adults by breaking open the earthen cells in which they were. They failed also to kill the wire-worms by any of the commercial fertilizers or insecticides, unless these were used in excessive quantities.

Prof. S. A. Forbes, State Entomologist of Illinois, proposes a rotation of crops in which the clover shall always follow grass, and corn shall always follow clover. Plow the grass in early fall, and sow clover, either with oats, wheat or rye. Allow the clover to stand two years and follow with corn. On general principles it is well to use wood-ashes where obtainable, because of their tonic effect on the plants. It is understood, of course, that these practices are recommended for aggravated cases of wire-worm infestation and not for regular use in the absence of the pest in dangerous numbers.

Corn and Timothy Bill-Bug.—The timothy and corn bill-bug is a small beetle that habitually works in timothy, where its work is naturally more or less obscure. When, however, corn follows infested timothy, or when corn is planted near infested timothy, it is likely to be attacked.

The beetles are less than one-fourth of an inch long, and are black. They belong to the group of snout-beetles. In young corn they tunnel directly into the plants just above the crowns, causing the plants to wilt and usually to die. Fortunately the beetle produces but one generation each year, and the injury, so far as corn is concerned, is done by the adult beetles alone.

While the bill-bug is known best by its work on corn, it is really timothy that suffers the most from its ravages. Working as it does in the bulbous roots of the timothy, it is able to pass unnoticed unless it occurs in very large numbers. Here in the timothy bulbs are passed the immature stages, the adults emerging at just the right time to attack the young corn. The moral is not to plant corn after timothy in places where one has reason to fear the presence of the beetles. When the beetles have once come out and done their work in the corn, there seems to be no danger from re-seeding, for there is but one generation each year and the beetles require timothy for their early development.

Cut Worms.—Just about the time that the danger from crows has abated somewhat, the young sweet-corn is often called upon to withstand an attack by cut-worms. There are striped cut-worms, dark, light, glassy, greasy and many other sorts, each belonging to a different species, and each developing into its corresponding moth. The moths or millers are nocturnal in their habits, and are spoken of as owlet-moths because of their habits and the shape of their heads.

Cut-worms naturally work on sod land, and for this reason, it is well to avoid planting corn, tobacco, tomatoes or anything else especially liable to their attacks directly after grass. Then too, the great majority of our cut-worms pass the winter in a partially grown condition, and when spring comes, and the sod and roots are replaced by a comparatively smaller number of corn plants, the worms are hardly to be blamed for feeding on them. Sod land, then, has its disadvantages when used before a crop liable to attack by cut-worms. It is also a menace when adjacent to a corn-field, for the worms will travel quite a distance from their breeding grounds in order to get at their favorite food. They work at night, traveling on the surface of the soil, and cutting off the plants low down at or just below the soil level. They cut off much more than they can use and then retire before daybreak, burrowing lightly and hiding often near the plant just cut off. One worm will forage night after night and destroy many times as much food as could be eaten. One can not help wondering at its wasteful habits. It has been suggested that the food is cut in order to let it wilt before it is eaten. Wet food does not seem to agree with some caterpillars, neither does that which is too vigorous and turgid. It is not unreasonable to suppose that much of the food is cut in order that it may wilt and be ready for future use, rather than from mere wanton destructiveness. As has been stated many of the cut-worms pass the winter in a partially grown condition, just beneath the surface of the soil. Occasionally, in winter, during a sudden thaw, the larvæ will crawl up on top of the snow, being driven upward by the water from the melting ice and snow. In such cases they seldom get back into winter quarters, but perish as soon as it freezes again. The writer has seen the snow thickly dotted with cut-worms on such occasions. Many parasites feed on them and shrews and birds devour quantities.

The measure that has been most successful in the past, is the use of poisoned baits, when the trouble is on a large scale. On a very small scale, other methods are more effective. Of the baits used, clover is the favorite. A goodly pile of clover should be cut, and while it is still fresh and green, it should be wet down with paris-green and water, using about half a pound of poison to a barrel of water, then, late in the afternoon, so that it will keep fresh as long as possible, twist bunches of this wetted clover in wads, more or less compact, and throw out over the field at short intervals. If the field to be protected be near a field in sod, then place an extra amount on the threatened side. The cut-worms love clover and oftentimes they will hide under such wads of fresh green food in the morning after a night's travel, eating a little of the poisoned food before hiding away. Poisoned pieces of turnips will do if clover is not to be had.

Poisoned bran, sweetened with a little molasses and made into moist balls the size of a plum, has been recommended, and Mr. Sirrene, of the New York State Experiment Station, recommends dry bran mixed with dry paris-green, sowed on the surface of the soil by means of a hand drill. In any case do not use such baits of bran unless stock and poultry are excluded or when partridge and quail are likely to get it, and do not expect to find the dead worms in the morning unless you are willing to sift the top soil for some distance about each bait, for the pests always bury themselves before dying. The only way to judge of the death of the larvæ is by the cessation of their work.

The habit of passing the winter in a partially grown condition or in the egg state, at once suggests fall plowing as a palliative measure, unless it be undesirable for cultural reasons.

The Sod Web-Worms, or Root Web-Worms.—Every observer of insect life has noticed, as he walks through grass on lawns or meadows in summer, multitudes of small white or grayish moths rising before him, flying a short distance, and then lighting to rest on the grass, head downward, with the body parallel to the blade. These moths, or millers, if examined when at rest, are seen to have the wings folded around the body in a way to give them a cylindrical form instead of the usual triangular one of ordinary moths. These are the parent insects of small, slightly bristly, reddish caterpillars which live abundantly in the turf, hidden away by day in a silk-lined burrow among the roots of the grass, but becoming active at night, when they feed especially upon the underground part of the stem of the plant, sometimes also upon its roots or blades.

These caterpillars average about half an inch in length when full grown, are pinkish red or brownish, and covered with rows of comparatively smooth dark spots, from the center of each of which springs a rather coarse hair. They differ from cutworms in their habit of quickly wriggling away when picked up or disturbed, and making active efforts to escape. Cutworms, on the other hand, are sluggish, and take disturbance quietly, simply curling up and taking their chances.

Not infrequently the web-worms become so abundant as to cause brown or deadened spots in a lawn or meadow, sometimes, indeed, in seasons unfavorable to the growth of grass, deadening the turf as thoroughly as white grubs or cutworms can do. When land so infested is planted to corn, this plant is very likely to be heavily injured, or even completely destroyed over considerable areas in early spring. The injury done is somewhat like that due to cutworms, and is largely under ground, but, on the other hand, the stems are rarely completely severed until the whole plant is eaten up. Commonly the first injury to the plant is done by gnawing the outer surface beneath the ground and about the roots. Then the caterpillar works upward, eating a superficial furrow or burrowing lengthwise along the center of the stem. The leaves are also frequently eaten, the lower ones first, and then the upper ones. The tips are eaten off, or irregular elongate holes are eaten through the blades. The injury being done at night, search must be made for the author of it by day by digging around the affected hills. The web-worms will commonly be found just below the surface, each in a retreat formed by loosely webbing together a mass of dirt, more or less cylindrical in shape, an inch and a half to two inches long, and about half an inch through. Within this mass is a silk-lined tube opening at the surface of the ground next to a stalk of corn, and within this specially prepared domicile a single caterpillar is secreted. Injuries due to these web-worms are commonly attributed by farmers to cut-worms, and the caterpillars themselves are similarly confounded. This error would signify but little except for a single important difference in the midsummer life history which has its bearing on the proper time of plowing the sod in spring, and that for planting or replanting the corn. Cutworms are never protected by an underground web, are much larger than web-worms, make no active efforts to escape when disturbed, but curl up and remain inactive, and are without rows of conspicuous shining spots upon the body, these being represented by small and inconspicuous ones.

The injury to corn by the sod web-worms is not uncommon in fields planted on sod ground, and as it begins quite early and may last some weeks, it is fully as serious as a similar attack by cutworms or white grubs. Frequently more or less extensive replanting is required, and sometimes whole fields are completely destroyed two or three times in succession.

Unless the damage they do is very serious it is hardly noticed, or, if noticed, attributed to other causes. As the larvæ live a retired life, close to the surface, eating mostly at night and remaining in their nests during the day, they are rarely seen. Like most larvæ they feed most voraciously just as they are completing their growth; consequently, when the damage is noticed most of the larvæ are hidden in their retreats where they pupate. In these places none but an experienced entomologist would find them, or would think of associating the damage done with the harmless appearing moths that fly later.

Hardly any farmer would think seriously of the loss of only one stalk of grass in ten, yet the aggregate for the country at large would be enormous. Not only is the damage to a crop where nothing short of a serious injury would attract attention, but the damage is distributed throughout the growing season. As a general rule, each species is most destructive at a different time from the other species of that locality; hence, species of *Crambus* prey upon the grass as a succession of small armies. Could the loss caused by these species come at one time in the year their destructive power would be better appreciated. Less than a third of the species may be classed as of economic importance, but these possess a capacity to cause almost infinite loss if the conditions are favorable.

Besides the injuries to corn, grass, and oats already mentioned, wheat and rye have been injured by *vulgivagellus,* tobacco by *luteolellus* (*caliginosellus*), and cranberry by *hortuellus,* a species not yet reported from corn. There are about sixty species of the genus *Crambus* in the United States. So far as known they are of very similar habit, and it is quite likely that any of them living habitually on grass will injure corn if this is exposed to their attack. The species notably injurious to this crop will consequently depend, in all probability, upon those which happen to predominate in the grass at the time the field is plowed, and as these predominating species differ from year to year, the list above given is not to be regarded as final.—(Bul. 95, Ill. Agr. Exp. Sta.)

The young caterpillars form their web-lined nests immediately upon or just under the surface of the soil, strengthening them by the addition of bits of grass or particles of dirt to the surface. They commonly cut off the blades of grass and draw the ends down into the nest so that they can feed without leaving it.

The facts concerning these web-worms all admonish the farmer to break up a grassy turf as early in the fall as practicable preliminary to planting the ground to corn; the middle of September is as late as safety permits. If, however, this is not done until spring, it may best be postponed, so far as web-worm injury is concerned, in most cases, until the latter part of May. If an infested meadow or pasture is plowed earlier than this, when the larvæ are still young, they will probably live to attack the corn when it appears; and if plowing is postponed later, until the first brood of moths have emerged, they are likely to lay their eggs in the grass before plowing, and thus to give origin to a brood of caterpillars, which, being quite young when the corn comes up, will make a long-continued attack upon it, against which replanting will be of no avail.—(Bul. 95, Ill. Agr. Exp. Sta.)

Burrowing Web-Worms. — These species, treated among the less important insects of the corn plant, are mentioned here merely to distinguish the larva of this group from the other web-worms, which it resembles somewhat in habit and injury to corn. It inhabits, however, a vertical cylindrical burrow penetrating the earth to a depth varying from six inches to two feet or even more. It is about the size of a common cut-worm, but differs by its dull velvety surface and its colors, varying from silvery gray to brown, by the rows of polished spots on the body, and by its greater activity and more loosely jointed structure.

The Stalk-Borer.—This well-known caterpillar, often called the heart worm because of the character of its injury to corn, may be at once known wherever it is seen by the peculiar break in the striping of the body at the middle. It is about an inch long when full grown. The general color varies from purplish brown to whitish brown, according to age, and it is marked with five white stripes, one running down the middle of the back, and two on each side. These side stripes are interrupted, being absent on the first four segments of the abdomen, giving the larva an appearance as if it had been pinched or injured there. The stripes nearly vanish as the larva matures. The head and top of the neck, and the leathery anal-shield at the opposite end of the body are light reddish yellow, with a black stripe on each side.

Its presence in a young stalk of corn is very clearly indicated by the wilting, breaking down, and death of the top, and by the presence of a round hole in the side of the stalk, plugged with the brown excrement of the caterpillar within.

It infests a great variety of other plants in a precisely similar way. It is most noticeable in early spring in blue-grass, by roadsides, or around the borders of a field, its presence there being betrayed by the whitening of single heads of the grass while all the rest of the plant is green. At this time it is of small size, and finds sufficient food within the grass stem; but later it is compelled to resort to thicker-stemmed plants, and it is at this time that it may appear in fields of corn.—(Bul. 95, Ill. Agr. Exp. Sta.)

Going in usually from outside the field, its injury is, as a rule, almost wholly confined to the outer rows. It rarely does any serious general damage to corn, and it has also been occasionally found injuriously abundant in fields of wheat. It is probable that where the injury is not limited to the margins of the field, but is general throughout its area, the eggs were laid in fall in grass or thick-stemmed weeds in corn-fields, where these have sprung up profusely after the corn has been laid by. The burrow which the stalk-borer makes within the stem runs upwards from the entrance opening, and of course varies in size with the growth of the larva. Sometimes in leaving a stalk it makes a new hole above that by which it entered, and it may in this way burrow in succession several different stalks and several different kinds of plants. Corn is injured by it while from two to ten inches high.

It is only one of several insects which produce this general effect at this time, but its own injury may be at once distinguished by the round hole which it leaves in the stem of the infested plant.

The caterpillar, when full grown, pupates, as a rule, within its last burrow, commonly below the opening at which it entered—seemingly a precaution against its destruction by the withering and breaking away of the upper part of the injured plant. The pupa is light mahogany-brown, about three-fourths of an inch in length, and bears at the tip of the body a pair of spines. From it comes out a fawn-gray or mouse-colored moth, with the outer third of the wings paler and bordered within by a whitish cross-line. Other specimens have some white spots on the disks of the wings. The moth is nocturnal, and has been taken by us flying about electric lights, and also at sugar. The eggs have not as yet been found.

There is but one brood in a year, and by the end of June the caterpillars are over half grown, and have mostly left the grasses in which they made their start and entered the thicker-stemmed plants, of course including corn.

Fortunately, injuries by this insect are not of a kind to require special measures of prevention or remedy. It is, of course, impossible to poison the larva in the corn-field, and the breeding habits of the insect are not such as to enable us to destroy it in the pupa state by any ordinary operation. If headlands and other grassy lots adjoining corn show in early spring an unusual abundance of these insects, it might be worth while to mow the infested turf and carry away and feed the cut grass promptly, before the caterpillars could escape to enter the corn.—(Bul. 95 Ill. Agr. Exp. Sta.)

*Larger Corn Stalk-Borer.**—In many southern cornfields a heavy wind late in the season, before the corn is matured, does great damage by breaking the plants off at the surface of the ground, thus ruining them. An examination of these broken stems will, in most cases, show that they have been greatly weakened by the burrows of a larva or caterpillar. This larva is known as the larger corn stalk-borer. Its work is largely within the stem of the plant and is so concealed that, in most cases, unless weather conditions make it conspicuous, the presence of the insect passes unnoticed.—(Cir. 116, B. of E., U. S. Dept. of Agr.)

This insect seems to have been originally an enemy of sugar cane and to have first transferred its attention to corn in the southern part of this country, where corn and cane are grown over the same territory. In the United States this borer is found almost universally throughout the South, from Maryland to Louisiana and westward to Kansas.

Corn is damaged by these caterpillars in two ways. First, in the early part of the season, while the plants are small, they work in the throat of the young corn, and if the tender growing tip within the protecting leaves is once damaged all chances that the plant will become a normal production specimen are gone. In many sections of the South this is commonly known as bud-worm injury, and though there are several other insects which cause a similar mutilation of the leaf, a very large proportion of the so-called bud-worm damage may be charged to this insect. The effect of its work on the leaves of the young corn plants is similar to that resulting from attacks by the corn billbugs and is evidenced by the familiar rows of small circular or irregular holes across the blades of the plant.

The other form of serious damage chargeable to this pest occurs later in the season. The larvæ, having then left the leaves and descended to the lower part of the stalk, tunnel in the pith. If the larvæ are at all numerous in the stalk, their burrows so weaken the plant that any unusual strain will lay it low and destroy all chance of its maturing.

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* See page 609, for illustration.

Peach Tree Sprayed with Lead Arsenate and Showing Partial Defoliation. Dept. of Agr.

Immediately upon leaving the egg in spring, the young larva of the first generation, spinning a silken thread behind it, wanders down into the throat of the plant as far as the water or dew usually standing there will allow it to go, and begins to feed on the leaves, going back and forth through yet unfolded clusters and soon riddling the more tender leaves with aimless burrows. If the burrow reaches the tender terminal bud where the future joints are being formed, further growth at that point ceases and the plant becomes stunted and misshapen, with no tassel. As the plant continues to mature, the larva grows out, as the farmers say. It is more likely that it is the evidences of its work and not the larva itself that grow out; but for whatever reason, the caterpillar soon leaves the more leafy portion of the plant and attacks the stalk at or near the ground. Here a hole is cut through the outer wall of the stalk and the larva burrows upward for a short distance, after which it seems to run aimlessly through the pith, frequently even leaving the stalk entirely and re-entering it at another point. Turning upward, the caterpillar, when fully grown, bores toward the outside and cuts a circular hole in the outer wall of the stalk. Then, after spinning a few loose threads across this opening to keep out undesirable visitors, it retreats a short distance, plugs the burrow below with digested pith, and in the chamber thus created slowly changes to the next or pupal stage.

The female moth varies in color from almost white to smoky yellow. The fore wings, which spread to about 1¼ inches, are darker than the hind wings, and bear faint markings. When at rest the wings are held close to the body, forming an acute triangle. The egg laying is done for the most part either at night or in the dusk of evening, the moths flying rapidly from plant to plant. The male moth is usually somewhat darker in color than the female and always smaller.

Rotation is one of the best general preventives of injury from insects affecting field crops. Experience has shown that where corn has followed itself upon the same field for two or more years there has been a much greater loss from the borer than where an annual change of crop has been practiced. This is especially noticeable where stalks or stubble from the previous year have been allowed to remain undisturbed throughout the winter. The moths, upon emergence in the spring, finding themselves surrounded by the young corn, commence egg laying at once and escape the dangers encountered in searching for another field of corn.

Another remedy, probably the best for this insect, is the thorough destruction, some time before the period of emergence of the moths in the spring, of all the stalks and stubble remaining in the field from the preceding crop. If all this trash can be disposed of before the opening of spring, the numbers of the pest must be greatly diminished if not almost exterminated, for the only form in which the insect passes the winter is that of the caterpillar, and the only known location is in the lower tip of the corn root, snugly hidden. Some few may, however, be found to survive in the roots of the larger grasses mentioned above, and care should be taken in such cases to treat these in the same way. The method employed in disposing of the stubble and stalks will depend largely on the conditions in individual cases. If the stubble is cut low and the land is moderately heavy, a thorough deep plowing may suffice, an inch or two of well-settled soil being sufficient to prevent the escape of the adult moths. Bringing the stubble to the surface where it can dry will kill some of the contained larvæ, but this method depends too much on the state of the weather to be trusted. By far the most effective plan is to remove the stubble from the field with a rake and burn it.

Any method which will insure the complete destruction of the over-wintering larvæ, if persisted in and carried out simultaneously over large sections of the country, will effectually preclude serious damage from the insect.—(Cir. 116, B. of E., U. S. Dep. of Agr.)

Corn Ear-Worm.—This is another general feeder which includes corn in its attacks. In the South it is the notorious "Bollworm" which is so destructive to cotton; it attacks tomatoes and a few other plants as well as corn. The presence of the caterpillar is first made known by small holes to be seen in the leaves enveloping the growing ear; on investigation the worm will be found devouring the milky grains and spoiling the ear by its excrement and the rot which usually sets in; sweet corn is especially liable to be spoilt by this attack. Any ear that is seen to be affected should be opened and the caterpillar destroyed; this seems to be the only thing that can be done. The moth is a handsome creature, ochre yellow in color, with darker bands across the wings, which measure an inch and a half when expanded. With us there is but one brood in the year, and much may be done to keep the insect in check by clean cultivation in the fall of the year.

In the great corn-growing States to the west and south the crop is very seriously injured year after year by the Chinch-bug, a small black bug, with a white mark on each side of the wings. As it appears in millions, these hosts inflict an enormous amount of damage by sucking out the juices of the plant.

The Seed-Corn Maggot.—This was observed during April and May, doing great damage to late-planted beans in the vicinity of Diamond Springs, Va. In certain areas rows were entirely killed off, necessitating replanting. As many as five to ten maggots were present in single seed beans and in many cases this number could be found in nearly every seed. It was noticed that the early-planted fields seemed to have escaped with much less loss. In one field the loss was estimated at about 85 per cent of all the beans sown. The beans were attacked just after sprouting, and when many larvæ are present they eat out the stem, radicle, and cotyledons.

This species also attacked the roots of cabbage in nearby fields. Small plants were generally selected for attack, and the wilted appearance of the leaves showed plainly which were the infested ones. These, when examined, proved to have numbers of maggots at the roots. Many of the plants were putting out roots above the points of injury, showing a strong recuperative tendency.

In its earlier stages, also, the seed-corn maggot resembles the house fly. The maggot is footless and cylindrical. It measures about one-fourth inch in length. The color varies from nearly white to pale yellowish. The maggot transforms into a puparium, barrel-shaped, and pale brown in color, measuring about 0.15 inch in length.

Owing to the difficulty of destroying root-maggots and other subterranean pests and the cost of chemicals for the purpose, growers depend largely upon methods of prevention. To be thoroughly effective these methods should be employed before the insect's eggs are laid.

For deterring the parent flies from depositing their eggs, place sand soaked in kerosene—a cupful to a bucket of dry sand—at the base of the plants, along the rows. This mixture will also kill young maggots that might attempt to work through it.

A carbolized form of kerosene emulsion is effective. This is prepared by adding to 1 pound of soap boiled in 1 gallon of water, one-half gallon of crude carbolic acid, and diluting the whole with from 30 to 50 parts of water. This mixture is applied about the stalks of the plants affected. It is best to use it a day or two after the plants are up, or are transplanted, and repeat every week or ten days until the danger period is passed.

Mineral fertilizers are useful as deterrents, particularly when employed just before or after a shower has thoroughly wet the ground. The principal fertilizers for this purpose are kainit, nitrate of soda, and sulphate or chloride of potash. They may be used as top dressings before planting; or, if not employed until afterwards, they should be applied as nearly as possible to the roots, the earth being turned away from the plants for this purpose. These fertilizers possess the advantage of acting also as a stimulant to plant growth, thereby facilitating recuperation from root-maggot attack.

Occasional Pests of Corn.—The Oat Thrips (see Insects Affecting Oats). The Fall Army Worm (see Insects Affecting Cotton). The Corn Ear Worm (see The Cotton Boll Worm). The Army Worm (see Insects Affecting Wheat). The Angumois Grain Moth, the Little Grain Moth, the Indian Meal Moth (see Insects Affecting Stored Products). White Grubs (see Insects Affecting Forage Crops).

PRINCIPAL INSECT ENEMIES OF GROWING WHEAT.

There are numerous insects, the number running into the hundreds, which feed on and injure growing wheat. Most of these insects are of rare or chance occurrence, and have no economic importance whatever, although the fact that they are found on wheat often leads the farmer to be curious about them or unnecessarily arouses his fears. The great proportion of the losses to wheat fields which is chargeable to insects is due to the attacks of less than half a dozen species. These, in the order of their importance, are the chinch bug, the Hessian fly, the wheat midge, and the grain plant louse. Of second-rate importance are such insects as the wheat strawworms, the wheat bulb worm, army worms, cutworms, and various sawflies. Then there follows a great horde of insects of minor importance which need not be considered in this connection. This is leaving out of consideration the locusts, or grasshoppers, including the Rocky Mountain, or migratory species, which occasionally injure wheat, but such injury is unusual and as a rule limited to migrations of locusts from one section to another, which are of infrequent occurrence nowadays, at least in the principal winter wheat growing regions, and have never been noteworthy except in the western districts. —(Farmers' Bul. 132.)

The Chinch Bug.—The chinch bug is certainly responsible for as great annual losses to farm crops as any other injurious species of insect known, and it is very improbable that any other species causes anything like the damage which is chargeable to this pest. This is due to its wide distribution, its prevalence more or less every year, the enormous multiplication in favorable seasons, and to the fact that it attacks all the cereals and most forage plants. Much of this loss undoubtedly can be avoided by a proper system of farm management and the adoption of known methods of control.

The important natural agencies responsible for the abundance or scarcity of this insect are not insect parasites, for it has none of any importance, but unfavorable climatic conditions and the various diseases induced thereby. The chinch bug is notably an accompaniment of drought, and very rarely, if ever, is serious injury caused by it in other than dry seasons. Wet weather is very prejudicial to it and develops various fungous diseases, which as a rule very promptly result in its practical extermination for the season.

From the standpoint of control no feature of the life history of this insect is so important as its overwintering habit. The general belief has been that the species hibernates beneath rubbish, such as old straw, or matted grass, or leaves in hedge rows, and this is probably often the case to a certain extent, but undoubtedly the normal place of hibernation is in the dense stools, especially of wild grasses, and also of such cultivated grasses as incline to the stooling habit.

The chinch bug goes through six different stages, from the egg to the adult insect. The egg is less than three-tenths of an inch long, cylindrical, and squarely docked at one end, in color pale or whitish when first deposited, but later showing the colors of the developing embryo through the shell. The newly hatched larva is but little larger than the egg and resembles the adult insect in miniature except in having no wings. It is of a pale reddish color, with a yellow band across the first two abdominal segments. The second larval stage resembles the first except in being larger, and having the head and thoracic segments dusky and hardened. After the second molt there is again an increase in size, and the head and thorax become still darker and more coriaceous. The next molt introduces the pupal stage of the insect, which resembles the adult almost exactly, except that the wings are replaced by mere wing pads, which latter had already been foreshadowed in the last larval stage. The next molt results in the perfect insect. Nearly two months are required to complete this life cycle.

After hatching the chinch bug is extraordinarily active in all stages, even the minute larva being able to travel rapidly and to extract itself from a considerable depth of covering soil if necessary. In habits this insect is distinctly gregarious, associating itself in masses on the plant attacked, commonly going by preference to the lower portions of the plant and, in the early larval stage, even working on the superficial roots.

The first brood is normally developed in wheat land, for the simple reason that when the chinch bug takes its spring flight wheat is the growing crop which is most likely to attract it. The wheat crop matures and is harvested, as a rule, before the first brood of bugs has reached maturity or at about the time they are entering the adult stage. The ripening and harvesting of the grain deprives them of food and induces a migration, and the young, half-grown, and adult insects start off together, apparently with a common impulse, abandoning the wheat fields and attacking any near-by cornfield or grass field. Their travels, while commonly much less, may extend to a distance of a quarter of a mile or more, and, as a rule, under these circumstances the bugs are numerous enough to completely carpet the ground. Entering a field of corn, they congregate on the outer rows at first, fairly blackening the stalks with their bodies and absolutely killing the corn as they move inward. As a rule, the serious damage is on the edge of the cornfields, sometimes, however, extending inward several rods.

If this midsummer migration is not induced by the harvesting of grain, or where the chinch bugs develop in other situations, their reaching maturity is immediately followed by midsummer flight to corn or millet or other crop.

Curiously enough, in the migration above noted the winged individuals, as well as the wingless, all crawl together on the ground, and flight seems never to be attempted on the part of the adult. The second brood, maturing about the last of August and the first of September, may have a partial flight to late corn or other late crops if the cornfields in which they develop have already matured and are drying up, but between the middle of September and the first of October they take what may be termed the autumnal flight to grass lands or other situations for concealment and hibernation.

For the practical control of the chinch bug many suggestions have been made, some of which have a good deal of utility. These are considered in the order of their importance. The hibernating habit of the chinch bug suggests at once the advisability of burning over and clearing up all waste land where this insect would be apt to congregate for overwintering. The burning of grass lands, especially the wild grasses which may have the stooling habit, should be done early in the fall so as to expose the chinch bugs that may not be killed by the flames as long as possible to the unfavorable action of the cold and freezing of winter. All the rubbish in the fence corners and hedge rows should be raked out and burned and as little material left as possible for protection of the insects. Cultivated meadows may be safely burned over when the ground is frozen without injury to the grass.

If a system of rotation could be adopted which would entirely disassociate small grains from corn, very little damage from the chinch bug would ever be experienced, at least to the latter crop. Following out this idea would mean the planting of a farm to corn one year and to wheat and small grains the next or some similar system of rotation.

In checking the midsummer migrating bugs some good may also be done by turning under the first rows of corn or other crop attacked. To have any practical value, however, the plowing must be done very deeply, or many of the bugs will escape.

The making of protecting furrows, as recommended for the army worm, is also applicable to the chinch bug. The bugs which collect in the furrow may be killed either by dragging a log along or by thoroughly wetting with the kerosene and water mixture.

A good deal of effort has been made in some places to protect fields by placing about them lines or barriers of coal tar. Where this is done the line of tar must be renewed several times a day. At intervals along it holes may be bored, in which the bugs will accumulate and may be destroyed. All that is necessary is to put a single straight line of tar in front of the migrating bugs and make holes on the side of attack with a post auger at distances of 8 or 10 feet close to the tarred line. Various other forms of barriers will easily suggest themselves, such as putting a line of boards about a field and smearing it with tar or combining the tar with the furrow method. Promptness and vigilance are the essentials in any of these remedial operations.

Summing up the subject of preventives and remedies, it may be said that the ones of real value are the clearing of farms and adjacent lands of rubbish and deadened grass by burning, the adoption of a rotation of crops which will separate the small grains from the later-ripening crops such as corn and late-sown millet, and the adoption of the steps indicated to stop the migrating midsummer hordes.

The Hessian Fly.—The Hessian fly is one of the principal enemies of the wheat crop, the minimum annual damage due to it being estimated at about 10 per cent of the product in the chief wheat-growing sections of this country, which indicates an annual loss of 40,000,000 bushels and over. An injury of from 50 per cent to a total failure of the crop is not infrequent in certain localities, and the resulting loss is proportionately greater.

The parent insect is a very fragile, dark-colored gnat or midge, about ⅛ inch long and resembling somewhat closely a small mosquito. As commonly observed, however, more or less hidden in the base of young wheat plants or other small grains, the insect appears either in the form of a footless maggot, or larva, or in what is known as the flaxseed state, which corresponds to the chrysalis of other insects. The injury to the plant is done altogether by the larva, which feeds on the tissues and juices and weakens and eventually destroys the plant.

The Hessian fly is distinctively a wheat insect, but will breed also in barley and rye. Over the bulk of the wheat area of the United States there are two principal broods of the Hessian fly annually, viz., a spring and a fall brood. There are, however, supplemental broods, both in spring and in fall, particularly in the southern wheat areas, but in the extreme northern area of the spring wheat belt there may be only a single annual brood, the progeny of the spring brood passing the late summer and the winter in the flaxseed state instead of developing a brood in autumn. It is possible, however, that in this region an autumn brood may develop in volunteer spring wheat.

Each generation is represented by four distinct states, viz., (1) egg, (2) maggot or larva, (3) pupa or flaxseed, and (4) matured winged insect. The eggs are very minute and slender, pale red in color, and are usually deposited in regular rows of 3 to 5 or more on the upper surface of the leaf. In the case of the spring brood they are sometimes thrust beneath the sheath of the leaf, on the lower joints. The number of eggs produced by a single female varies from 100 to 150.

The whitish maggots hatch in from three to five days and crawl down the leaf to the base of the sheath, embedding themselves between the sheath and stem, and develop on the substance of the wheat, causing more or less distortion and bulbous enlargement at the point of attack.

In a few weeks the larva contracts into a flaxseed-like object, which is the puparium. In the case of the spring brood the insect remains in the flaxseed state during midsummer, yielding the perfect insect for the most part in September; in the case of the fall brood the winter is passed in the base of the wheat in the flaxseed condition.

The fall brood works in the young wheat very near or at the surface of the ground. The spring brood usually develops in the lower joints of the wheat, commonly so near the ground as to be left in the stubble on harvesting. With spring wheat the attack is sometimes just at the surface of the ground, as in the case of the fall brood. The adults from the wintered-over flaxseed puparia emerge during April and May, most numerously before the middle of the latter month. The adults of the important fall brood emerge chiefly during September.

The important feature in the life history of the Hessian fly from the standpoint of control is the time of emergence of the fall brood or broods of adults. This arises from the fact that the chief means of preventing loss from this insect is in sowing late enough in the fall to avoid infestation. Unfortunately, also, it is not possible to give a uniform date for seeding which may be relied on year after year.

The first indication in the fall of the presence of the fly in wheat is the much darker color of the leaves and the tendency to stool out rather freely. This is very noticeable, and gives the wheat for the time being a very healthy appearance. The leaves are also broader, but the upright central stems are wanting, having been killed by the fly. Later, the infested plants turn yellow or brown and die in part or altogether.

The excessive stooling, or tillering, of wheat attacked by the fly is doubtless due to the natural tendency on the part of the plant to offset the injury by forming new lateral stems, and therefore a wheat that has a natural tendency in this direction is less apt to be seriously damaged by the fly. Other things being equal, also, wheat with stiff, flinty stems is less damaged by fly attack, chiefly because the straw does not bend or break so readily at the point weakened by the spring brood of larvæ.

It is practically impossible to save a field once severely attacked by this fly, and under such circumstances it is better to plow the wheat under deeply and plant to corn or other spring crop. A crop of wheat may be partly saved, but in the main the measures of really practical value against this insect are, of necessity, chiefly in the direction of preventing future injury. These are all in the line of farm methods of control, and are arranged in the order of importance as follows:

As already indicated in the paragraphs on habits and life history, late planting of winter wheat is undoubtedly the best and most practical means in normal seasons of preventing damage in regions where infestation is to be anticipated. The most that can be advised under this head, however, is to give a general statement covering normal years and climatic conditions. The actual date after which planting may be safely made must necessarily be fixed for each locality separately, and be subject to yearly modification to meet varying seasonal conditions. In a general way, to avoid fly injury, planting should be made in the northern winter-wheat districts after the 15th or 20th of September, and in the more southern districts between October 1 and 15. If the right time be selected, neither early enough to be attacked by the fly nor yet so late as to cause danger of winter killing, much of the damage in normal seasons to winter wheat from this insect may be avoided.

The fact has been noted in the life history that the second brood develops in the lower joints of the wheat and is left, for the most part, in the field in the flaxseed state at harvesting. All these individuals may be destroyed by promptly burning the stubble. Burning may be more easily effected if a rather long stubble be left, and especially if it be broken down by rolling. If the burning of the stubble be neglected until the rank growth of weeds has sprung up which usually follows harvest, it will be well to run a mower over the fields, cutting off the stubble, weeds, and grass as close to the ground as possible, and burning over as soon as the weeds and grass dry sufficiently. Careful burning will very largely prevent an abundant fall brood of flies, and may be supplemented by burning all screenings of the wheat if thrashing precedes the fall appearance of the fly.

In line with burning, and of nearly equal importance, is turning the stubble under by deep plowing, and afterwards rolling the field to compact the earth and prevent any flies which may mature from issuing.

The regular practice of a system of rotation in the growth of crops is of the utmost importance in avoiding damage. Its value may be offset at times by invasion from neighboring fields of wheat on other farms, but usually comparative freedom from attack will result and the benefit will extend to the other crops coming in the system adopted in checking the insect enemies of these at the same time.

The supplemental fall brood antedating the principal brood will come to nothing if all volunteer wheat be plowed under or destroyed within a few weeks after its appearance. This is of especial value in the North, where spring wheat is grown, and where the brood developed on the volunteer wheat may be the principal means of carrying the insect through the winter.

The Wheat Midge.—The wheat midge is another dipterous enemy of wheat, allied to the Hessian fly and the wheat bulb-worm by belonging to the same order of insects, but is entirely distinct in appearance and habit. The adult insect is a very minute gnat or midge, not exceeding one-tenth of an inch in length and varying in color from orange to yellow, but tarnished or slightly smoky-tinged on the back above the wings.

The injury occasioned by this insect to wheat and allied grains is by its orange-yellow larvæ or maggots to the forming embryos in the wheat heads. The milky juice is extracted by these larvæ from the young kernels without any apparent gnawing of the surface, causing the grain to shrivel and the heads to blight and be imperfectly filled. On occasions of unusual outbreaks of this insect the crop is sometimes completely ruined, and occasionally the losses over whole States have averaged from two-thirds to three-fourths of the entire yield, or amounting to many millions of dollars. Damage to this extent is, however, unusual, and the wheat midge, while ranking as one of the chief insect enemies of the wheat crop, is commonly much less dreaded than the Hessian fly or the chinch bug.

The period of attack of this insect in early summer depends very much on the season, being retarded by cold and hastened by warmth. Ordinarily the fly appears about the wheat by the middle of June, and is present depositing its eggs for two or three weeks. In wet seasons it may even remain in evidence until the middle of August. Dryness is inimical to it, and unusual moisture is very favor able for its operations. It is especially active on cloudy days and at night. Wheat grown in low, moist land is therefore more subject to injury, and if unusually dry weather prevails during the period when the fly is depositing its eggs, little injury is done to the wheat crop, and, correspondingly, a wet season at the same period is liable to result in greater loss on account of this insect.

The exceedingly minute, oval, nearly cylindrical eggs, pale red in color, are deposited singly or in clusters to the number of ten in the crevices in the wheat heads, most often at the extremity of the head, and usually in the crevices and openings which lead to the developing kernel. In about a week the eggs hatch, and the larvæ find their way at once to the kernel or germ.

The life of the larva is about three weeks. The full-grown larva is fairly robust, oval in shape, and has a length, when in a quiescent state, of about eight-hundredths of an inch. When in motion, it extends somewhat and tapers markedly toward the anterior extremity. It now abandons the wheat head and descends to the ground. Many of the larvæ are still in the wheat heads when it is harvested and are carried away from the field when the wheat is stacked. Their vitality under these circumstances is something extraordinary, as they are able to survive for months without moisture or food. Those that enter the ground in the fall form minute cocoons not larger than a mustard seed, and when covered with dirt, as they usually are, are almost impossible of discovery. It is believed that they remain unchanged in the ground until the following spring, or probably until shortly before the appearance of the adult insect again in the wheat fields in June.

This insect is another one of the grain pests the ravages of which are not subject to immediate remedy in the field. The only steps of importance are in the line of prevention of future injury. A practical preventive suggested by the hibernating habit of the insect is in the deep plowing of the old wheat fields to bury the larvæ so deeply in the ground that they can not escape the following year. As a further preventive, the chaff and screenings from the thrashings of wheat from an infested field should be promptly burned. The practice of rotation of crops is also applicable to this species and will be of value in proportion to the isolation of the fields or to the generality of its adoption.

The Wheat Plant-Louse.—This plant-louse is not one of the principal insect enemies of the wheat crop, but in some years, fortunately widely separated, it multiplies in enormous numbers and over wide regions, and becomes almost as destructive and occasions almost as much loss as does the Hessian fly or the chinch bug. Local damage is of more frequent occurrence, and the species, in fact, occurs every year more or less, and often arouses fears which, for reasons to be subsequently explained, are not realized.

The wheat plant-louse appears on winter wheat in September in the form of wingless females, which rapidly reproduce themselves, going through several generations. It occurs about the base of the wheat and on the roots, remaining in evidence as late as September 30. During the fall this louse does little damage to wheat growing in good, fertile soil, and after the lice leave, the plants, as a rule, soon recover. On poor soil, however, wheat may be seriously injured at this season. The method of over-wintering has never been discovered, but it seems probable that it hibernates on the wheat in the egg stage. At any rate, the wingless female lice reappear on the wheat early in April and remain in evidence, passing again through many generations, until harvest. Throughout the spring and early summer it works on the stems and leaves above ground. Later it moves to the wheat heads, and very frequently these are simply filled with clustered masses of lice, which now assume a brownish-orange color.

A rainy and fairly cool spring and early summer are favorable to the plant-louse, because, while not checking its own multiplication to any degree, and, in fact, favoring it, the conditions described prevent its predaceous and parasitic enemies from operating to any extent. As a rule, therefore, the drier and warmer weather commonly preceding harvest enables these natural enemies to gain the upper hand and quickly exterminate the lice, and this is commonly accomplished soon enough to prevent material damage to the crop.

No remedy is possible in case of attack by this insect, since direct application of insecticide to growing grain is out of the question, and there are no mechanical means of destroying the lice. One can only await the providence of the weather conditions and the action of natural enemies. As already pointed out, in the great majority of seasons, and often when the lice appear in the spring in numbers, unfavorable weather and the natural enemies effectually prevent appreciable damage.

The Wheat Straw-Worms.—The wheat stems or culms are subject to the attacks of the larvæ of certain minute insects belonging to the parasitic groups of the order Hymenoptera, which is represented by the parasites of the Hessian fly, plant-lice, etc. This little group or subfamily to which these wheat species belong has diverged from the great mass of its allies and acquired a strictly vegetable feeding habit instead of subsisting parasitically on other insects. Several of these species feed on wild and cultivated grasses, and several others on the various small grains. The two species which are especially destructive to wheat are known as the wheat straw-worm and the wheat joint worm. The habits of these two insects are similar and result in similar injuries to the wheat crop, namely, weakening the stems or culms and causing them to break and fall before the grain is ripe, and at the same time weakening the plants and decreasing the yield.

The Wheat Joint-Worm.—This insect was long confused with the joint-worm of barley, the habits of which it exactly duplicates. It is a true gall insect, its presence being indicated by the oblong swellings or enlargements caused by the larvæ in the walls of the wheat stems. The galls are commonly found at or near the joints, and more commonly the second joint, but may occur in the vicinity of nearly every joint on the stem.

The adult insect is a minute, black, four-winged fly, measuring in length from an eighth to less than a quarter of an inch, and closely resembles in appearance its own Hymenopterous parasites and also the parasites of the Hessian fly and like insects. The galls usually occur in groups of three or four, and sometimes in large numbers together, greatly deforming and weakening the stem.

On cutting these galls open they will be found to contain when mature the joint-worm larva, yellowish white in color, with its jaws or mouth-parts tipped with brown. In the larval and pupal stages this species resembles its ally, the straw-worm. This species is believed to be single-brooded, and to hibernate in its galls in the wheat stems in the larval stage, transforming to pupa and adult insect in the following spring or early summer.

The Wheat Straw-Worm.—This insect is very closely allied to the joint-worm. It is distinguished, however, by its habit in living free within the hollow stems or culms of wheat, and producing no gall or deformation in the walls of the stem, as do the former species. Its work within the stem is indicated by the eaten and torn inner surface, and as a rule it does not occur in as great numbers as does the joint-worm. It winters in the stem in the pupal stage instead of the larval stage, as does the joint-worm, and is double-brooded.

The adults of the two broods of this insect are quite dissimilar in appearance, and have been described as distinct species. The adults, consisting of both sexes coming from the over-wintered pupæ, are rather minute, and the females are wingless or with the wings greatly aborted and functionless. The eggs of this brood are deposited about the last of April or early in May near the embryo head of the wheat, which at this season is only a short distance above the ground. These develop and produce the adult of the second generation in June. This generation is much larger and more robust than the spring generation, and consists entirely of females provided with fully developed wings. They are therefore capable of flying readily about and constitute the migratory brood. The eggs from this brood of large-sized females are deposited in or near the joints of the straw, more frequently near the second joint below the head. The worms on reaching maturity enter the pupal or chrysalis stage in the fall and emerge as adults the following spring.

The damage from the wheat straw-worms is not often of a serious nature, but is quite general, and is probably very commonly overlooked on account of the concealed habits of the larvæ, and this is especially true of the wheat straw-worm, the falling of the grain being often attributed to other causes.

The remedy for both of these insects is in burning the stubble which harbors the over-wintering stages. This burning may be done either directly after harvest or at any time during fall or winter, or prior to the earliest emergence of the adults, which may begin by the latter part of March.

The Wheat Bulb-Worm.—The parent of the wheat bulb-worm is a minute two-winged fly or gnat, not at all related to the Hessian fly, except in its habit of breeding in wheat and various grasses, and the damage due to it is doubtless very often confused with that done by the more dreaded species.

The wheat bulb-worm fly is a native American species, and doubtless originally bred in various wild grasses. It is known to attack timothy and blue-stem and other grasses, and also rye, oats, and barley, as well as wheat. It is not nearly so destructive an insect as the Hessian fly, yet sometimes causes considerable loss. The flies appear in September and October and deposit eggs (less than 0.025 of an inch in length) on the young wheat plants. The pale watery-green footless maggots hatching from these eggs work their way down between the leaves to the crown of the plant and feed on the central part of the stem, cutting it entirely off and causing the central blade to discolor and die. These maggots pass the winter in the wheat, at the point indicated, and transform to pupæ in April and May and emerge as adults in June. An adult is about one-fifth of an inch long, greenish in color, and marked with three longitudinal black stripes on the back (thorax and abdomen). The eggs of this brood of flies are deposited, often several in a row, usually near the edge of the sheath of the upper leaf, so that the larvæ or maggots coming from them can readily penetrate the succulent portion of the stem just above the last joint, where they remain feeding on the stem and eventually killing it, causing the upper portion of the straw to wither and die and the head to blight or turn white. The second brood of adults escapes from the straw in July and August and breeds in volunteer wheat or various grasses, developing a third brood of adults in time to infest the winter wheat in September and October.

The chief remedy for the Hessian fly, namely, planting of wheat, does not, unfortunately apply to this closely allied pest, because the adult females of the latter are known to occur abundantly up to October. If grain can be thrashed promptly after harvest and the straw and stubble burned, it will doubtless effect the destruction of a great many of these pests, or if the grain be removed from the field as soon as practicable after being harvested most of the insects will be carried away and will not succeed in escaping from the center of the stacks at least. Rotation of crops as a preventive applies also to this insect, but even this remedy loses some of its value from the fact that the species breeds in various grasses. Fortunately, some important parasitic and predaceous insects usually keep this grain pest in check, and it is therefore unusual for it to assume a very injurious role, although widespread and frequently occasioning more or less loss.

The Army Worm.—Damage to wheat from the caterpillars commonly known as army worms and the injury caused by the allied cutworms, which come in the same category, are of such an intermittent or occasional character that the farmer can hardly be expected to take regular precautions to prevent the attacks of these insects. Severe injury is witnessed, as a rule, only at comparatively long intervals at a time in any one region, although injury probably occurs every year in some part of the country or other in varying amount. Where farms are carefully and cleanly cultivated, and not contiguous to waste or swampy land, and ground to be planted in wheat is early plowed, damage from these pests will not often be experienced. The more serious army worm outbreaks are most common in the months of May and June, or sometimes as late as July, when wheat, oats, and other small grains, corn, timothy, and various grasses, with the exception of clover, are occasionally suddenly overrun by multitudes of the dark-colored, naked, striped caterpillars of this insect. These hordes of larvæ usually travel in one direction, passing from one field to another, destroying crops as they go. They have a habit, also, of climbing the stalks of such grasses as timothy and the small grains and cutting off the stems just below the head.

The adult insect is a pale or yellowish-brown moth, with a white spot on the center of each fore-wing. Its minute white eggs are usually laid in numbers from two to three to twenty in strings beneath the sheaths of grass stems, a strong effort evidently being made by the female moth to conceal her litter. They are occasionally deposited also in other situations or beneath the leaf sheaths or loose bark of other plants. The eggs hatch in from eight to ten days, and the young caterpillars feed for a time in the fold of the leaf, but grow rapidly and soon consume entire leaves.

Under ordinary circumstances the larvæ feed mainly at night, or in damp, cloudy weather, remaining hidden during bright days, resembling in this habit the closely allied cutworms. They reach full growth in three or four weeks, attaining a length of 1¼ inches, burrow into the ground, and transform into brown chrysalides. In this condition they remain in the summer an average of two weeks before yielding the perfect moths.

Several generations are produced each season; two or three in the Northern States and four or five or perhaps six in the Southern States. The army worm, as a rule, passes the winter in the half-grown larval condition, occasionally in the South hibernating as a moth, and perhaps rarely in the egg stage.

This insect is present in grass land probably every year in greater or less numbers, but on account of the habit of concealment of the larva it is very rarely noted. It attracts attention and becomes a matter of grave concern only when, as a result of a series of favorable years or exceptionally favorable local conditions, it suddenly develops in enormous numbers and is forced by scarcity of food and hunger to migrate in swarms from its breeding grounds, and travels and feeds both during the day and night.

The over-wintered larvæ appearing suddenly in spring may occasionally attract notice, but as a rule the notable and destructive swarms are the progeny of the first, second, or third summer broods. In general, it may be said that these worms are more apt to make an injurious appearance in a rainy spring or early summer following a season of comparative drought.

As already noted, the fact that the army worm occurs at very irregular intervals—usually widely separated, and as a rule without warning—renders it impracticable to get farmers to undertake preventive measures. In general, however, it is true that clean cultivation and the adoption of a regular system of rotation of crops in which grass lands are alternated every few years with cultivated fields will keep this insect in check and probably prevent an unusual multiplication of it. Bearing in mind also the fact that it breeds normally in rank grass and over-winters in such situations, it is of importance to burn over such tracts early every winter, which will kill many of the larvæ and leave the others to be destroyed by exposure. If these measures be practiced the army worm will probably never be able to get a migratory start, or, in fact, become abundant enough to necessitate migration.

One of the best remedies available in this latter direction is the old-time one of plowing a furrow with its perpendicular side toward the field to be protected and the subsequent dragging of a log through the furrow to keep the earth friable and kill the worms which have accumulated in the ditch; another is to poison heavily with Paris green or London purple in solution a strip of pasture or field crop in advance of the traveling army of worms. In the same line is the distribution of quantities of a bran, arsenic, and sulphur-sugar mixture across their line of march. The general destruction of the worms themselves by direct application is hardly practicable, and as a rule they can be safely left to the action of their natural parasites, which at this season are apt to be very much in evidence.

The Wheat Sawflies.—There are quite a number of sawfly larvæ which are occasionally found in wheat fields. Most of these have very little economic importance and are only chance migrants to wheat from various wild grasses on which they normally feed. When seen, however, by the farmer they often arouse fears and are charged with damage with which, very likely, they have nothing to do.

The adult insects are four-winged flies, belonging to the order Hymenoptera, which includes the bees and wasps. They are termed sawflies in description of the sawlike ovipositor of the female insect with which she makes incisions in the tissues of plants for the insertion of her eggs. The larvæ of the species working on wheat either bore the stems or feed externally on the leaves. The stem-borers are the more distinctively wheat pests and are capable of doing much more damage.

Stem-Boring Sawflies.—Two species may be especially noted as being of possible importance in this country: First, the so-called European corn fly and a native species which occurs in California and works in a similar manner in the stem of a hollow grass.

The adult flies appear in April and deposit eggs in the stems of the young wheat. The larvæ bore through the joints and work up and down the full length of the stem. When full grown they attain a length of half an inch and are milky white in color. With approaching harvest they pass down to the bottom of the stem and cut the straw circularly on the inside, nearly severing it. Beneath this cut they form a little cocoon at the base of the stem, within which they pass the winter in the larval stage, transforming to pupæ and emerging as adult insects the following summer. The object of the cut made just above their cocoon is to cause the straw to break and allow the perfect insect to more readily escape from the stem, and the damage done by this insect is chiefly in the falling or lodging of the grain which often results from the weakening of the straw at the point indicated. Otherwise very little harm results, and the heads of attacked wheat are, as a rule, well filled.

This insect breeds in wheat in preference to other small grains. In fact, it is doubtful whether it often successfully develops in other grains than wheat and rye, although the females will oviposit in oats and even in the stems of grasses.

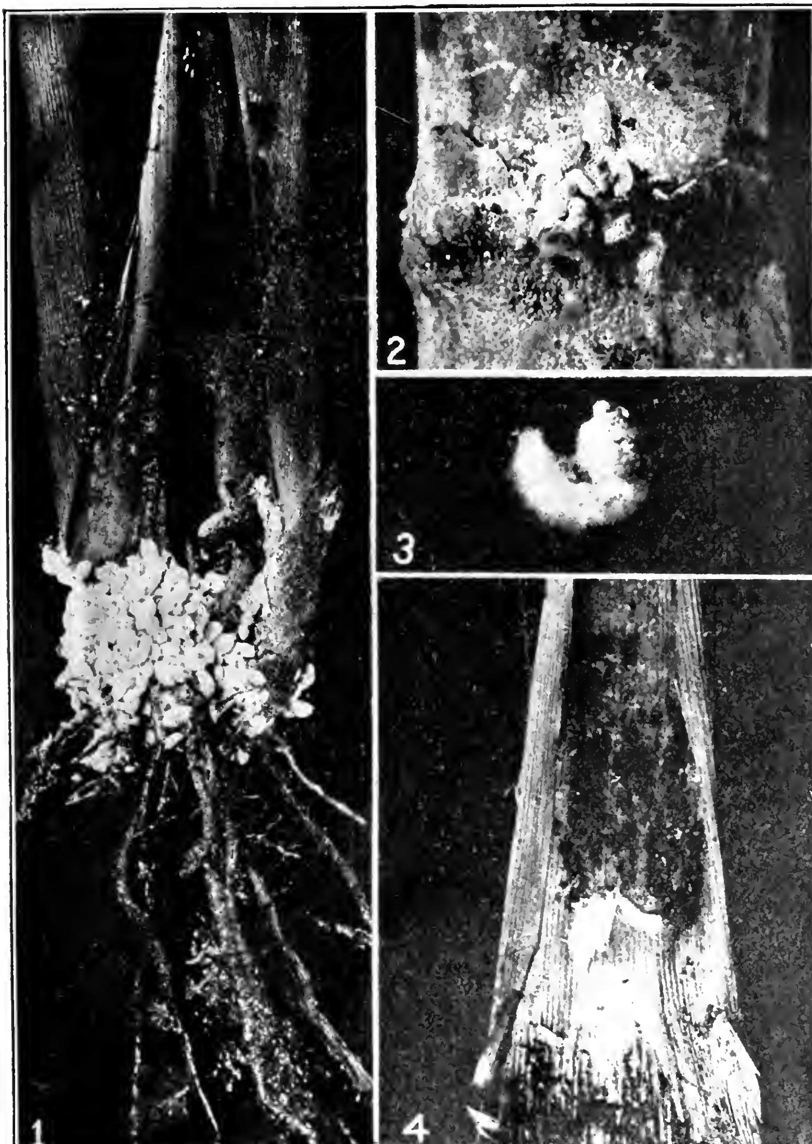
Western Wheat Sawfly.—This insect is in habit exactly similar to the European wheat sawfly, and the adult insect closely resembles the European species. Its economic importance arises from the fact that it may at any time be expected to abandon its native food plants in favor of the small grains, in which it can undoubtedly successfully develop. Such changes in the food habits of our native insects are being constantly witnessed, as is illustrated by several of the species already discussed and the leaf-feeding wheat sawflies, which normally affect wild grasses.

Leaf-Feeding Sawflies.—As already indicated, several native American sawflies occasionally attack growing wheat. These are all species which normally feed on wild grasses. The larvæ of some half dozen species have been found on wheat. The adult insects of all of these are similar, and the species may be taken as a characteristic representative of them. It is a blue-black fly, somewhat larger than the house fly, very sluggish in habit and ordinarily found in swampy places on grass in early spring. The larvæ of these insects attain a length of nearly an inch, are usually dull or dirty whitish in color, with the head marked with brown. Some of them are also marked with brown stripes or spots along the side of the body. They occur, as a rule, singly, and are rarely in sufficient numbers to be of any economic importance.

Grass Sawfly.—A more important species is a grass sawfly about the size of a common house fly, which occurs throughout the Northern States east of the Rocky Mountains. The eggs of this insect are inserted in rows along the edge of the blade of wheat, or more commonly in grasses, and the larvæ hatching from these feed on the leaves more or less gregariously while young. As they become full grown they separate and become practically solitary feeders. They may be distinguished from the latter, however, by being uniformly yellowish green in color, with the head similarly colored, with the exception of the two minute brown eyespots, and by the possession of seven instead of eight pairs of abdominal feet.

This species, also, can scarcely be considered as having great economic importance. So far as they work on the leaves of the wheat their damage is inconsiderable, but occasionally they are attracted by the green portion of the stem just below the head, especially as the wheat ripens, and sever the stalk at this point, causing considerable loss.

The fact that damage from both the stem-boring and leaf-feeding sawflies has never been very considerable in this country has made it unnecessary to adopt any special precaution with regard to them. Where land is deeply plowed and replanted in the fall both the stem borers and the leaf feeders will be buried too deeply to escape. The only danger, therefore, comes from land that is left in stubble over winter or long enough for the adult insects to emerge in spring. Should any of these insects ever assume any especial importance, they can doubtless be kept in easy control by seeing that



Sugar Cane Mealy-Bug. Fig. 1, Adult Mealy Bugs Clustered About Base of Young Cane. Fig. 2, Adult Female, Twice Natural Size. Fig. 3, A Single Adult Female, with White Mealy-Like Covering. Fig. 4, Cocoons of Male Mealy-Bug. Dept. of Agr.

(See pages 11 and [illegible])

all wheat-stubble land is deeply turned under with the plow in the fall or winter. The likelihood of serious infestation from neighboring grass lands is not great, although not to be ignored.—(Farmers' Bul. 132, U. S. D. A.)

INSECTS AFFECTING CLOVER, GRASS, AND OTHER FORAGE CROPS.

Clover Root-Borer.—Undoubtedly the most destructive enemy of clover is the root-borer, a creature which was unknown in Michigan up to about twenty years ago, but which has now become well distributed. Originally from Europe, the root-borer was accidentally imported into America without the natural enemies with which it had to contend in its native home. Here it has found the land of promise and fulfillment.

Usually the first acquaintance with this pest is made sometime after the field has been cropped for one season. The field will not look just right and a few plants will be pulled to see if the roots are healthy. Affected plants are apt to break off at the level of the ground. On examination the roots will be found to be tunnelled, the cavities being blackened and often containing the tiny beetles or the grubs, sometimes eggs will be found if the tunnels are examined with a good lens. Further search is apt to reveal a good many plants in the same condition.

Seldom, if ever, does the root-borer work in clover plants before they are a year old—that is, one year from the spring following the sowing of the seed. The first spring directly following seeding, the roots are too small to attract them, and after that they escape until the following spring, owing to the habit of the beetle of migrating only at the spring season, usually in early May. There is but one generation each year.

The winter is passed in the tunnel, for the most part, in the adult stage. Migration occurs usually in early May, new fields are attacked and tunnels made, so that by the latter part of May the eggs are laid, packed away in the dead parts of the roots and covered up with refuse. Toward the latter part of summer the larvæ change to pupæ in the burrows, to become adult beetles by fall. Both larvæ and pupæ feed on the substance of the roots. Mammoth clover suffers most of all. Common Red clover (June clover) nearly as much and alsike less.

The beetles themselves are very small, being rather less than one-eighth of an inch in length. They are reddish-brown in color. The eggs are smooth and white, and the larvæ are white with yellowish-brown heads.

We find one encouraging feature in the whole situation, in that the beetle never attacks until the plants are one year old. True, they have not done much in the way of growing by that time, but they have made a start and are ready to produce hay. During the season after seeding, the field usually escapes with a minimum of injury, but after that time there is apt to be trouble. We must be content with one season's crop of clover, instead of a succession of seasons of clover meadow produced by re-seeding, as was customary before the root-borer came. It forces us to keep up a short rotation with clover as with everything else. Now as to the plowing of the field. Professor Webster, then of the Ohio Station, advised plowing immediately after cutting, and before the larvæ had pupated, if possible, exposing the roots to the drying influence of the wind and sun, thus drying out the larvæ and starving them.

Clover Stem-Borer.—Of minor importance as a crop destroyer is the stem-borer. The adult is a smooth, polished and slender beetle, about one-fourth of an inch long, with red head and thorax and with dark, steel-blue wing-covers. This beetle lays its eggs inside the clover stem in the spring, and the larvæ from the eggs tunnel up and down through the stem, maturing and emerging in the fall. They injure the plant somewhat by weakening the stem. It is an insect to be found scattered over the clover fields, but we have never seen it in numbers sufficient to do appreciable injury.

White-Clover Stem-Weevil.—On one or two occasions reports of marked injury to white clover have been made, accompanied by a number of specimens of the small snout-beetle known as *Sitones.* It is a yellowish-brown snout-beetle, about three-sixteenths of an inch in length, and with a short, thick beak. The body and the legs are covered with very short, dense hairs, those on the underside sometimes having a coppery tinge. Professor Webster reports severe injuries to white clover and to alsike; circular or semi-circular pieces being eaten out of the leaves by adult beetles. The larvæ are described as about three-sixteenths of an inch in length, with a dirt-colored head and white body, tapering quite markedly at the hind end. The work of the larvæ is normally in or on the stems, where they feed on the soft inner parts. The winter is said to be passed in the partly grown larval stage, pupation occurring early in spring. Occasionally, Professor Webster says, adults may hibernate. On July 5th adults were plentiful, and larvæ that were no doubt the larvæ of this creature, were reported present in the soil. It is likely that a drenching with kerosene emulsion may prove useful in case of infested lawns.

Clover Butterfly.—Closely resembling the common cabbage-butterfly, in size and general appearance, is the yellow butterfly or clouded sulphur. Many believe that the cabbage butterfly is either white or yellow, but this is a mistake. The cabbage-butterfly is white and gray, or white and black, and the yellow one is an altogether different creature, living in its larval condition on clover, and its relatives; vetch, lupine, peas, etc. The larva resembles the cabbage-worm somewhat, being green with either yellowish or pinkish stripes, bordered below with black on the sides.

There are three generations each year, but the injury wrought by these dainty yellow creatures is not known to be anywhere near as serious as that inflicted by their white relatives, the cabbage butterflies, perhaps because they are distributed over such wide areas and because their work is more obscure.

Clover Drasteria.—This measuring-worm is fairly common in clover fields. The larva is brown and gray, striped, and about one and one-fourth inches long. It progresses by a method of looping steps like a measuring worm. When full-grown it spins a cocoon in a little nest prepared by tying a few leaves together, wherein it changes to the pupal condition to emerge soon as an adult moth. The moth is prettily marked with grayish and brown. It measures about one and one-half inches from tip to tip of its extended wings. The flight of this moth is jerky and quite rapid. When disturbed it flies a short distance and usually dives behind some plant, going into hiding, where it remains some time unless disturbed. There are several generations each year, but in spite of this the increase is seldom sufficient to destroy a crop. Among the remedies suggested for its destruction is fall plowing, preferably in October. We would add that plowing is really not necessary in the majority of cases, because the injury is usually slight.

Clover Leaf-Hopper.—A small leaf-hopper about one-eighth of an inch in length is the clover leaf-hopper. Prof. Herbert Osborn and H. A. Gossard, then of the Iowa Station, describe this creature as feeding voraciously on clover, besides several other plants, such as sugar beets, cabbages, rutabagas, and blue grass. It is an insect of minor importance, and is one of the pests that hibernates in rubbish. When it demands attention, clean culture is indicated.

*Clover Leaf-Beetle.**—Among the important enemies of clover must be reckoned the leaf-weevil, a snout beetle which arrived here only in comparatively recent years, and whose native home is Europe. The adult beetle is dull-brown in color, much lighter on the sides, and covered with minute, yellowish hairs. It has a stout beak, or snout, curled downward and backward under the body, but clearly visible in profile. The beetle is plump, and about three-eighths of an inch in length. It is quite commonly seen during the autumn on roadside plants, on sidewalks and on buildings, etc. For the most part, at least, the winter is passed in the larval stage, the young grubs or larvæ attacking the fresh clover plants in the spring, feeding on the leaves. At night they venture boldly out and devour the leaves, but during the daytime are more or less concealed near the bases of the plants. In appearance these larvæ are almost slug-like, footless, and green in color with a lighter stripe running down the back. They reach the length of about half an inch when full grown, at which time they spin beautiful fine-meshed, lace cocoons, usually, though not always, at the surface of the ground. The cocoons are elliptical and about three-eighths of an inch in length, and of a light-greenish color. In July and later the beetles appear, feeding also on the clover plants.

Fortunately for us the clover-weevil, which has all the characteristics of a first-class pest, is kept in check by a fungous disease, a fungus that flourishes on the living bodies of the larvæ and kills them in great numbers. Curiously enough, larvæ attacked by the disease are impelled to climb up on spears of grass around which they wrap their bodies and die. The spores or seed-like bodies of the fungus are thus thrown to some distance, and falling on other larvæ spread the disease. Epidemics of the disease usually follow attacks of the weevil, so that it is ordinarily held in check and reduced to

* See illustration on page 357.

small numbers before much harm has been done. Large numbers are sometimes killed at once, so many as to show plainly on the tips of the spears of grass, when one looks along the tips from a level near the ground. The writer has seen the color of a patch of clover and timothy changed from a bright green to a marked greyish tint by the dead bodies of the larvæ, each on its grass leaf.

Now this is all very satisfactory thus far. The fungus ordinarily keeps the beetle in check, and if it stopped at this point all would be well. But unfortunately the dead bodies of the larvæ are filled with the substance of the fungus, and this is said to be poisonous to stock if eaten in sufficient quantity. Mr. G. C. Davis, formerly of the Michigan station, reports the serious illness of cattle which was clearly due to eating quantities of the dead larvæ, although no fatalities resulted. We have since that time received accounts of similar occurrences. For this reason it will be well to avoid pasturing stock in fields full of the dead larvæ until they have had time to shrivel and fall to the ground.

Clover Mite.—The clover mite is not a true insect but a near relative. It is responsible for much of the whitening of the foliage of clover and some other plants. It is a tiny creature with eight legs. The color is dark red. Minute spherical eggs are laid on trees in the fall, where they are often the cause of alarm among fruit growers, who are apt to consider them some form of scale. The main reason for disliking the clover mite, however, is not because of injury done to clover, as that is too obscure to be much felt. The tiny mites have a habit of crawling into buildings in the spring and in the autumn, where they get on furniture, books and tables. They are so fragile that it is next to impossible to even brush them off, they crush so easily leaving a red stain. This is especially disagreeable when they crawl into open books or between papers. A closing of the books or a shifting of the papers is sure to result in tiny, red blotches.

The best way of keeping these mites out of buildings is to spray the outside of the foundation walls with kerosene, or to coat them with a narrow band of some sticky mixture, such as tangle-foot, printer's ink, or something similar. It is probable that the lime and sulphur sprays, in common use at present, will help to destroy the mite by destroying the eggs.

Destructive Pea-Louse.—Pea-growers, especially those raising peas for canneries, sometimes have difficulty with a green plant-louse of small size, which collects in astonishing quantities on the vines. The same creature is to be found living, at almost any time, on clover and crimson-clover. It is impossible to do much in the way of control when the insect is on clover nor is it often necessary.

Clover-Head Caterpillar.—According to Professor Gillette and Professor Osborn, there are three generations each year with sometimes a partial fourth generation. The tiny moths lay their eggs in the clover heads and the larvæ, usually one to a head, feed on the forming seeds, destroying all or part in each head. The winter is passed in the larval stage and pupation occurs early in the spring. The caterpillar is greenish-white or pale yellow without markings, with a brown head, and sixteen legs. It is about one-fourth of an inch long. The adult moth is brown. Spring plowing (done before the end of April) or fall plowing will destroy the third generation. Early cutting of the first crop, as is recommended for the seed-midge, should destroy the first generation, and where this is common practice it is unlikely that the head caterpillar will become very serious.

Clover Thrips.—At any time before the middle of the summer, a clover head, if torn apart, is likely to reveal a number of tiny red or black creatures, which run quickly about in attempts to hide. They are thrips. The immature thrips are bright blood-red, becoming darker as they grow older, the adults being black. The general appearance is quite similar to that of the oats thrips. These little creatures are so small and are provided with such feeble mouth-parts, fitted for scraping only, that individually they are capable of doing only a slight amount of injury. In the aggregate it is reasonable to assume that they must blight quite an appreciable number of heads or parts of heads, but thus far no one has devised a practical method of controlling them. Fortunately they are most plentiful early in the season at a time when it does not make so much difference. All thrips thrive best in hot, dry weather.

Crimson Clover-Seed Chalcid.—When crimson clover was introduced into America, it was hoped and believed that we had a substitute for red clover that would at least be free from the enemies of red clover. The trial proved, however, that crimson clover seed was preyed on by a pest, more troublesome than those of red clover seed, and further that the new pest was liable to spread from the crimson to the red clover. A close examination of the seed showed the kernels to be hollowed out by the tiny creatures, each infested seed containing a tiny, black, wasp-like winged insect, belonging to a family most of the members of which are parasitic in their habits.

There are two broods each year. The tiny chalcids are slightly more than one-sixteenth of an inch in length, and jet black in color. The hulls from which they emerge show each a little, round hole through which the insect has come. If this were the whole story no one would grieve much, but, unfortunately, Dr. A. D. Hopkins, then of the West Virginia Station, reports that they work in developing seeds of red clover as well. It is not at all impossible that on some of the occasions where the red-clover crop has failed, this newer pest has been to blame. The writer has searched many times and has had many samples of clover seed sent in from all over the state for the purpose of finding the cause of such failure, but thus far has been unable to find the characteristic hulls, possibly because they are so light as to be blown out by the separator.

Dr. Hopkins reports that the insect winters in seed left in the open field, evidently in the larval stage. This would suggest fall plowing when the presence of the pest in a given field is established and when such practice is practicable. Prof. F. M. Webster suggests burning stems and hulls after hulling and the destruction of all outstanding clover heads, as a remedy worth trying.

Clover-Seed Midge.—When we consider the large amount of clover seed, the depredations of the tiny seed midge become of alarming importance. So small and frail is this creature that one almost doubts its ability to injure anything. Nevertheless, most of the failure of June clover and mammoth clover to seed is due to it, and possibly to the clover-seed chalcid with which it is sometimes confused. The life-history of this creature is well known, and fortunately we are able to so time our cutting as to take advantage of the creature and thus secure a crop of seed most of the time. A brief review of the life-history is as follows:

The light-yellow eggs are laid just inside the flower tubes at the time when they are beginning to show color. After a short time the eggs turn red in color, hatch, and each one produces a tiny maggot which travels down inside its flower tube to attack the soft seed forming at its base. This seed is known as the ovule at this stage, and it furnishes just the right sort of food for the maggot when in this soft condition. Later, when the ovules commence to get hard, they are safe from attack since the mouth parts of the maggot are feeble.

In the ordinary course of events, when the first crop of clover is cut late, the maggots descend to the ground, bury themselves, and change to puparia, which stage corresponds to the cocoon stage of moths, later they transform to minute flies, much smaller than mosquitoes, which are just in time to lay their eggs in the coloring clover-blossoms of the second crop. These if undisturbed reach the pupal stage by winter, in which condition they remain until spring, ready to produce the crop of flies which once more lays its eggs in the first crop of clover.

In appearance these flies are very frail little creatures, brownish in color and very small, being only a little more than one-eighth of an inch long. They swarm about the clover-heads during the egg-laying season, but are not often observed because of their small size and dull color. Usually the presence of the midge is unsuspected until after threshing time, when the tiny pink or salmon colored larvæ are found mixed with the threshed out clover seed. Sometimes as much as one-fourth or one-third of the product is made up of tiny maggots, which if not understood are very alarming to the farmer, who suspects them of having designs on his seed. All suspicion of wrong doing is unfounded, however, since all the harm was already done before the clover was cut, the maggots being powerless to injure the dry, hard seed.

As already stated, the development of the second crop of clover flowers and the development of the second generation of midges have to occur simultaneously in order for the young seeds to be in just the right condition for food at the time when the young maggots hatch out from the eggs. This is likely to occur if the first crop is cut during the time when the flowers are turning brown. If, on the other hand, we cut the first crop just as the color is beginning to appear, then the second crop of clover is pushed ahead of its normal time a week or more, and the young ovules or seeds become hardened before the second generation of midges have emerged and are ready to lay their eggs. Also many larvæ and pupæ are no doubt destroyed by the early cutting, and the ones that do succeed in finding places for their eggs, have to put up with inferior and belated heads, few in number. Now it is well known among many clover growers that early cutting of the first crop is the best insurance possible for a crop of clover seed.

During the past few years, the presence of the crimson clover-seed chalcid has been reported in June clover in other states; and failure to get a good crop of seed, when there seems to be no other explanation, may be due to the presence of this pest. It is needless to say that all volunteer clover should be destroyed.

Clover-Hay Worm.—Supposing that a crop of clover successfully evades the leaf-beetle, root-borer, and all its other enemies, and that it has been stowed away in the mow or stack. One would think that at last it should be free from danger. There is, however, one more insect pest to which it is exposed, viz., the clover-hay worm. This pest, the larva of a pretty little miller or moth, feeds on the dried hay, eating a small amount, but tying up by means of webs, and thereby ruining, many times that amount of good hay. It prefers the bottom and edges of a mow to work in, and here it is likely to bind the hay into felted masses, which stock refuses to accept. It spins a silken thread wherever it goes and besides this spins a cocoon of a tough nature, tucking it away in the hay, and between the hay and boards, giving the hay the appearance of being molded. The brownish caterpillar or larva is very active when captured or disturbed, wriggling away and dropping suspended by a single thread which it spins as it falls.

The hay worm remains over from year to year in the old hay and to control it we have only to feed out all the old hay and clean the mow before each new crop is put in. In the case of stacks, burn up the refuse and build the new stacks at a little distance. If only a little refuse remains in the bottom of the mow, clean it out and burn. Never put new clover hay on top of old when the hay worm is present or has been recently.

Clover Mealy-Bug.—Occasionally we find old clover fields infested by a mealy-bug, which lives on the roots. This tiny sucking insect lends its aid in impoverishing the plants, usually in company with the root-borer. Especially is this true in sandy land and in fields that have stood several years in June clover or mammoth clover. We have never seen fields seriously injured by this creature. It is usually kept in check automatically by rotation in this state, where clover is commonly used for green manuring.—(Mich. E. S. Bul. 258.)

The Cowpea Curculio.—The cowpea curculio, hitherto known as the cowpea-pod weevil, is found to be very abundant and destructive in some sections. This beetle is bronze-black in color, about a quarter of an inch long, with the thorax and elytra deeply and abundantly pitted. Damage is caused by cowpeas by punctures made in the pods and peas by the adults for the purpose of feeding and oviposition and by the feeding of the larvæ within the maturing peas. The damage, though seemingly widespread, is not very evident, as it affects the value of the crop only where the peas are grown for seed. More serious injury is done by this species in early spring to young cotton, which it is forced to use for food. Individual cotton plants or the entire stand in a field may be injured or completely destroyed.

The distribution of this weevil probably coincides with that of the cowpea, but since the injury to cotton is more noticeable it has seldom been reported from beyond the cotton belt. It is, without much doubt, of southern origin and has probably spread northward following the introduction and use of the cowpea. In the spring cotton is often damaged seriously while it is small by the adult beetles, but as this trouble occurs only on land on which cowpeas were grown the preceding year it is apparent that cotton is a food plant from necessity rather than from choice. Later in the season beetles in confinement have starved to death rather than feed on nearby young cotton.

When full grown, the larva cuts a hole to the outside of the pea and then through the pod and drops to the ground. The opening in the pod is frequently at some distance from the injured pea. It is quite regular, circular in outline, about 2 mm. in diameter, and the disk which is cut out often remains hinged at one side. After dropping to the ground the larva immediately begins to burrow into the earth. The larger and more active grubs burrow deeper and more rapidly. After reaching the necessary depth, the larva by the motion of its body proceeds to form an oval cavity somewhat larger than itself. It spins no cocoon whatever. After entering the ground the larvæ do not pupate at once, but remain quiescent for several days in the earthen cells.

The cowpea curculio passes the winter in the adult stage, going into hibernation when its food supply is destroyed in the fall with the first severe frosts. The beetles winter, hidden under rubbish or lumps of earth or buried from 1 to 3 inches deep in the earth itself. The beetles emerge from hibernation as soon as the weather fairly warms up.

In so far as cotton is concerned, the sovereign remedy would seem to be to refrain from planting it on land previously occupied by cowpeas infested with this pest. Planting cowpeas with the cotton would probably cause the beetles to confine their attentions to the former plant. The larvæ, as a rule, do not emerge from the pod until the pods are well ripened. If therefore the crop is being grown for seed the pods may be gathered frequently as they ripen. If stored in a tight, dry bin the larvæ as they emerge will be unable to complete their development.—(Bul. 85, Part VIII, U. S. D. A. B. E.)

The Smoky Crane-Fly.—The maggots or larvæ of the *Tipulidæ* are known in the several parts of this country by many local names, among which, perhaps, the most generally applied are meadow-maggots, leather-jackets, grubs, and cutworms. The larvæ, for it is in the larval stage of development exclusively that these insects are of economic importance to the farmer, are really the young of several species of crane-flies—also known as gallinippers, giant mosquitoes, and daddy-long-legs. The last name, however, is sometimes applied to the eight-legged and wingless harvest-spiders. Early in October the adults of this species are abroad in great numbers among tall, rank grass, clover, and weeds, from which they rise awkwardly, as one approaches, flying but a few yards before alighting. They continue abundant in the field during the greater part of October.

The larvæ, which often occur in enormous numbers, as many as 200 having been found in an area covering a little over 1 square foot, feed upon the roots of various plants, seeming to prefer the *Leguminosæ,* and contrary to most published accounts of the habits of these larvæ, they not only suck the juices of the roots but devour the plant tissue itself, as is evidenced by the stomach contents of several larvæ examined in this office. Moreover, the well-developed biting mandibles would indicate a tissue feeding habit. They feed during the early fall and hibernate as half-grown larvæ, resuming activities in the spring. In feeding, these larvæ move about in the ground quite freely, as is evidenced by the small molehill-like ridges which they leave, in going from plant to plant just under the surface of the ground. They become full grown about the middle of July, form perpendicular cells about 3 or 4 inches underground, and remain inactive until about the middle of September, when they pupate. The pupal stage lasts from a week to ten days.

Several remedial measures have been recommended against tipulids in general by different writers, from time to time, among which might be mentioned sprinkling the ground with salt, herding sheep and hogs in infested fields, and rolling the ground with a heavy roller. Probably the best method of treating an infested field is to plow the sod under in the early fall and either to run the field into corn, potatoes, and such crops, or to leave it fallow the ensuing summer. Pastures and hay fields in localities where this species is known to be abundant should be grazed off by the middle of September and kept so until late in November, as the adult flies usually congregate in rank growths of grass, clover, weeds, etc., and there lay their eggs.—(U. S. D. A. B. E. Bul. 85, Part VII.)

The Alfalfa Weevil.—This insect is not native to America, but has been accidentally introduced from Europe, western Asia, or northern Africa, where it is common, and where, while more or less destructive to alfalfa, it is probably prevented by its natural enemies from working serious and widespread ravages. Just where or in what manner it was brought to this country no one knows, but it was first discovered in the spring of 1904 in a small field of alfalfa near Salt Lake City, Utah, and attention promptly called to its presence there by the entomologist of the Utah Agricultural Experiment Station.

The beetle itself is usually less than one-fourth of an inch in length, varying from one-eighth to three-sixteenths inch, and when freshly emerged from the cocoon within which it passes from the larva to the pupa is of a plain brown color. In a few days this brown becomes darker, mixed with black and gray hairs, which give it a spotted or mottled appearance. Gradually these scales and hairs become rubbed off, so that in spring we frequently observe individuals that appear almost entirely black, with small, irregular gray spots upon them.

The insect winters entirely in the beetle stage, seeking shelter, before the frosts of autumn commence, either in the crowns of alfalfa plants, close to the surface of the ground in the field, or under leaves, matted grass, weeds, and rubbish along ditch banks, haystacks, and strawstacks. Indeed, it is oftentimes found in barns where the hay is kept over winter. When this hay is being put into the barn in late summer, one side of the barn has been observed to be almost covered with adults, and in winter and spring, when the hay is being fed out, the floor of the barn will often be swarming with the beetles, like ants about an ant hill. It has been estimated that fully 80 per cent of the beetles that go into winter quarters in the fall live through until spring. With the coming of spring the beetles make their way forth from their hiding places and attack the young growth of alfalfa as soon as there is sufficient food for them. In ordinary seasons they may be expected to appear the latter part of March, and the egg-laying period usually lasts from early April until early July.

In very early spring, before the plants have made much growth, the beetles often push their eggs down between the leaves, the usual place of oviposition, however, being in punctures made in the stem, and some damage occurs at the very beginning of the season on account of the beetles puncturing the young stems and killing them in their efforts to oviposit in them.

It would seem, therefore, that the efforts of the farmer should be, first, to endeavor to restrict the pest as effectually and as long as possible to its present area of infestation, and, second, to use every means in his power to control it, in the meantime, within this area.

The most inexpensive and practical means of controlling introductions of the pest by railroads appears to be in the close surveillance of the railroad right of way and the stamping out of incipient outbreaks as soon as discovered. This, too, seems a duty likely, at least for the present, to devolve upon the Federal authorities, as nearly all of the States adjoining Utah are without the means of carrying such a plan into operation, and a year at least would be required to put into operation the legislative measures necessary to meet the situation. Therefore, the greatest assistance can be afforded by the growers of alfalfa personally, especially along railways and near towns and villages, by keeping close watch of their fields and promptly notifying the Government or State authorities of the occurrence of any insect resembling this alfalfa weevil, as described and illustrated herein. It is chiefly for the purpose of reaching such person and of promptly obtaining information as to the first appearance of the pest in any locality that this circular is published.—(U. S. D. A. B. E. Cir. 137.)

The Alfalfa Caterpillar.—The insect under consideration in this circular is the caterpillar of one of our most beautiful and common butterflies, belonging to the group known as the yellows, and is closely related to the well-known cabbage butterfly. The name yellows at once gives one an idea of the appearance of the adult, but this may be misleading, the coloration varying from a bright yellow (very frequently noticed), through an orange-sulphur (the most commonly noticed), to a pale white (the least often noticed). For some years past the green caterpillars of this butterfly have been reported from various localities in the southwestern United States as feeding on and in some cases doing a large amount of damage to growing alfalfa. It should be mentioned here that it is the caterpillar or worm stage of this species that does the damage, and not the adult butterfly. The latter feeds on the nectar of the bloom and in no way injures the plant. In fact, the writer has noticed these butterflies to all appearances springing the pollen triggers on the alfalfa blossoms while feeding, thus, should his observations prove correct, benefiting the plant for seed production.

It is on ranches and fields from which successive crops of hay are taken that the height of the damage is reached. In such fields the conditions for the development of the species are as nearly ideal as possible, and here the worms are ordinarily unmolested in their feeding and growth. The period elapsing from the time that one crop is cut until another is ready to harvest so nearly coincides with the length of the period necessary for the development of any one generation of the butterfly that the cutting of the hay, as ordinarily carried on, does not reduce their numbers or disturb their work, since the worm will likely be in the advanced stage or, perhaps, have passed into the pupal stage before the crop is cut off.

Many fields observed were attacked in strips or patches. Sometimes one border would be almost totally devoured, while an adjoining plot would not be molested. Again, in other fields irregular patches would be attacked and the rest of the field not materially injured. In cases where whole borders of alfalfa were injured, the time and amount of water applied in irrigating produced an uneven growth, and as the generation of butterflies, on issuing, chose for egg-laying the strip that was the greenest and freshest, this strip would be the one damaged. It seems possible to account for the irregular patches in the same way—that is, considering that these patches were ones that were held back because of the condition of the soil. The soil conditions in one part of the field may be quite different from those in another part of the same field, and thus a varying growth of the crop results, which would be attacked in patches.—(U. S. D. A., B. E. Cir. 133.)

Do not abandon a field because the caterpillars are beginning to damage a hay crop. If the caterpillars threaten the destruction of a crop of alfalfa before the hay can possibly mature, mow it at once, cutting it low and clean, and in so doing starve a large majority of this generation of worms, thereby protecting the next crop as well as saving a part of the one already affected. Get the ranch in the best possible cultural condition. Irrigate often and thoroughly and as soon after cutting as the crop of hay can be gotten off the ground. Cut close to the ground and clean, especially along the ditch banks, borders, and turnrows, as well as in the main part of the field. Cut the crop early. When just coming in bloom is the proper time. Watch for caterpillars in the early spring crop, and if many are observed about grown cut the hay a few days before it is in bloom, and thus save the next crop. Pasture alfalfa whenever possible, as a minimum amount of damage occurs in such fields.

Use the methods just mentioned on early spring crops, no matter whether any worms are noticeable or not, and thus avoid any risk of having overlooked them. The satisfactory results must come from an application to an early crop. Renovate every winter, either by disking or by the use of an alfalfa renovator, thus disturbing any pupæ that may be wintering over, and putting the land and alfalfa in condition for good growth the following spring.

These methods, while they will probably be of value in other sections, have been tried only in the Imperial Valley of California, and they are not specifically recommended for sections where climatic and other conditions differ from those found in this valley.—(Cir. 133, U. S. D. A. B. E.)

The Grass Thrips.—The adults pass the winter at the bases of the grass stems just above the ground. In the spring as soon as the weather is sufficiently warm to start the grass, they become active and begin to deposit eggs, continuing to do this for from four to six weeks. The eggs are deposited in the tissues of the fresh and tender parts of the leaf, and one female may lay quite a number, individuals kept in confinement averaging from fifty to sixty each. The length of time between egg-laying and hatching appears to vary somewhat according to the weather. Eggs laid in early spring hatch in from ten to fifteen days, but during the summer much less time is required. When the egg hatches the young thrip works its way up out of the leaf till it is nearly free, where it remains until its body has sufficiently dried, when it pulls itself entirely out and soon begins feeding. When full grown it is about four times as long as when it left the egg.

The full grown larvæ or young, now seek for some protected place in which to pass through the next stage of life—the pupa. Sometimes the place selected is between the stem of the grass and an upper leaf sheath, but usually it is in similar places at the base of the stem near the ground. Here they move about but little, doing no feeding. In this condition they remain for a few days, at the end of which time, the outer covering is thrown off and the adult insect appears.

The adult insects are of two kinds, viz., those with wings and those without. Over 90 per cent of those of this first spring generation are winged, and are thus able to fly and infest new fields.

They appear early in May and at once begin laying eggs for another generation, which passes through the same stages from egg to adult as the first brood, the history of which has just been outlined, except that less time to produce a generation is required as the weather grows warmer. During the season therefore, there is time for eight or nine generations to complete their life histories, each year. As fall approaches, however, fewer winged adults appear, more wingless ones being produced, until in October only about 2 per cent are winged. Egg-laying by the last generation of adults may continue until snow comes, but only the adults appear to be able to survive the winter.

The amount of injury done by these minute insects is little appreciated on account of their small size, but what they lack in this regard is made up by their numbers. It has also been noted that while the increase appears to be extremely rapid during the early summer months, the heavy showers of midsummer appear to destroy many of the insects.

The adults of this species feed entirely upon the leaves and external parts of the grass. They are very seldom found within the sheath of a leaf, but frequently congregate in numbers within the terminal leaf before it has fully unrolled. They select the fresh tender parts of the grass, and consequently their work is most apparent upon the upper leaves. The mouth parts are used to pierce the surface of the leaf and the wall of a cell below. As soon as the juices contained in this cell have been extracted, the piercing mouth parts are withdrawn and another cell is punctured, the empty cells presenting a shrunken, whitish appearance. The insects usually feed lengthwise of the leaves, their path being marked by whitish streaks in the tissue of the leaf and by dots of dark excrementitious matter.

The young seek a more protected place in which to feed, and may be found in large numbers within nearly every sheath of June grass during the latter part of May and through June. A favorite haunt is in the head, just as it is making its appearance. The minute young work their way down inside the sheath, and some of them, reaching a node where they must stop, continue to feed upon the juices from the very tender stem within until shortly before they enter the pupal stage. The young may be found within any sheath; but it is almost always those that enter the top sheath which cause the silver-top, as these directly cut off the supply of sap to the head. Examination of affected stems shows that at a point just above the upper node the stem has been sucked dry for about half an inch of its length.

This minute pest attacks a number of species of grass, but by far the greatest damage is done to June grass, few fields of this escaping more or less serious injury. After the first of July, by which time June grass has usually matured, the insect changes to some later species, as timothy when this is present. They may be found in abundance upon barn-yard grass from mid-summer till late in the fall.

A knowledge of the life history of this insect suggests to us a few ways in which it may be most easily combatted and its damage lessened. As the females hibernate above ground, burning in early spring must destroy large numbers of them. To be effective, the burning must be close and thorough, and the burned space either quite large or isolated from other infested fields. This must be done before the grass starts, which is usually about the first of April, because the females hibernate very close to the base of the stems, and a close burn after the green blades appear cannot be obtained.

The damage appears to be most severe on worn-out meadows, fields and lawns. This suggests stimulating the plants, to give them additional vigor, and harvesting as clearly as possible. The June grass should either be cut as soon as the heads begin to turn white, or be fed green. Attacks are most severe on fields that have been seeded for several years and have become partially exhausted. This suggests ploughing deeply, and planting for at least one year with some cultivated crop before reseeding.—(Bul. 67, Hatch Mass. Agr. Exp. Sta.)

Grasshoppers.—The several injurious species of grasshoppers occurring in Colorado undoubtedly occasion heavier annual loss than any other single insect pest, not excepting the codling moth. It is the object of this brief paper to give the most important information as to the habits of these destructive insects and the remedies that may be used against them.

All our specially destructive grasshoppers spend the winter in the egg state in the ground. The eggs are from about 3 to 4-sixteenths of an inch in length, cylindrical in form, yellowish white to yellowish brown in color and are deposited in compact masses of from about 20 to as many as 75 together. The females dig small holes to the depth of an inch or a little more with the stout ovipositor at the tip of the abdomen. The abdomen is then thrust in as far as it will reach and a gluey material is exuded and smeared over the inner wall of the little cavity making it firm. Then the egg mass is deposited and it is also covered with the gluey material which soon hardens and protects the eggs from excessive moisture and from being easily crushed. Egg-laying of some of the species begins about the first of August and continues until hard freezing late in the fall kills all the old females. As a rule, a single female deposits two packets of eggs.

The places most chosen by the females for the purpose of egg-laying are ditch-banks, the borders of fields and road sides. The egg packets are also most often found about the roots of plants, as alfalfa, clover or weeds. If the eggs are at all abundant, a little digging about such plants where the grasshoppers were numerous in the fall will usually reveal them.

The eggs begin to hatch about as soon as vegetation starts in the spring and continue for several weeks, but the eggs of a single pod all hatch together. The young hoppers begin at once to feed upon such tender growing plants as are at hand various common weeds entering largely into their diet. When young and wingless, they are inclined to remain rather close to their place of hatching but as they grow they scatter about more and may become quite evenly distributed through a large field. The tendency to remain together in large flocks is more or less marked however, and particularly is this noticed late in the afternoon when they congregate along the borders of the fields and upon the fences to spend the night. So marked is this habit that where grasshoppers are abundant it is a common sight to see a strip from ten to thirty or more feet wide about the borders of an alfalfa field that is almost denuded of vegetation. Sometimes the grasshoppers do great damage by ascending trees and eating fruit and foliage and gnawing the tender bark from the twigs. Such injuries usually occur alongside an alfalfa or pasture field from which the grasshoppers have migrated.

There are many remedies that may be used to advantage against grasshoppers. Which is best to use in a given case depends upon circumstances. It may be best often to use a combination of remedial or preventive measures. The best of all artificial remedies, where it can be used, is plowing deeply late in the fall or early in the spring, all the ground where the eggs are abundant. Even the young hoppers, when very small, may be turned under quite successfully in this manner and destroyed. Where plowing cannot be resorted to, a thorough harrowing, especially with a disk harrow, will do much to destroy the eggs. Some will be crushed, others will be eaten by birds and still others will succumb to the freezing and thawing and drying when separated from the egg-mass. These remedies must be applied before the young hoppers hatch.

When the grasshoppers are quite small and travel slowly, they may be killed along ditch banks and in other places where they are abundant by covering the ground with straw and then burning it.

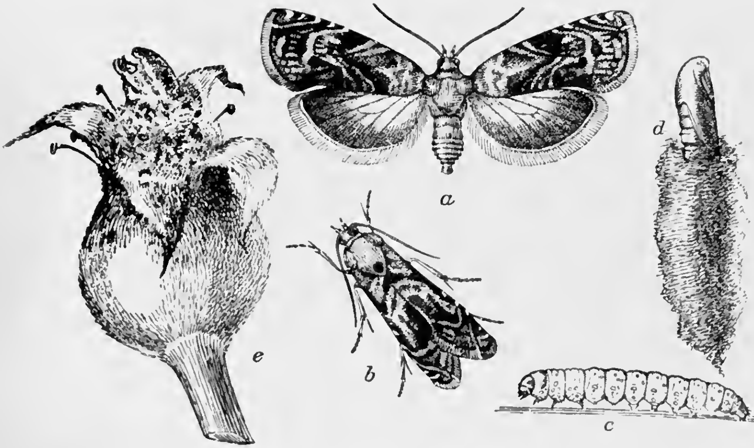
Young hoppers may also be poisoned in large numbers by thoroughly spraying the young weeds and other vegetation on the waste land where they are hatching in large numbers with any of the arsenical poisons, as Paris green, arsenite of lime, arsenate of lead, etc. The poisons should be used rather strong. Later, when the hoppers get into the crops, they may be poisoned quite successfully by the use of arsenic-bran mash. Mix a pound of Paris green or white arsenic with about 20 pounds of bran, moisten enough with water so that the particles will adhere together in a crumbly mass, and then sow broadcast where the hoppers are most abundant. Do not use this where chickens feed.

To keep grasshoppers out of trees, bandage the trunks with cotton batting or printer's ink or axle grease. If either of the last two named substances is used do not put it upon the bark of the tree but upon heavy paper which is first wrapped about the trunk. If the hoppers jump or fly into the trees, using poisonous sprays or driving with whips will have to be resorted to.

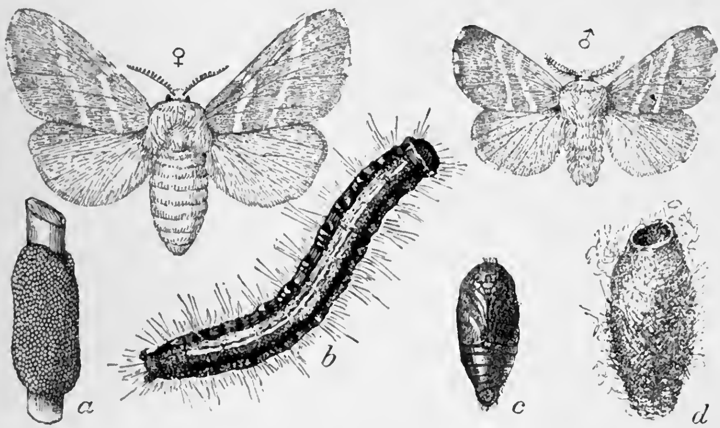
Hopper-Dozers.—For open fields, the hopper-dozers, or catchers, are probably our best remedy after the grasshoppers have hatched. The pan is made of sheet iron and the back is extended by means of upright stakes and a strip of muslin. In the pan is placed a quantity of kerosene or crude petroleum, or a small amount of water with oil upon the surface and the pan or dozer is then drawn over the field by hand or by means of a couple of horses kept well apart so as to collect the hoppers. If the horses are in front of the middle of the pan, many of the hoppers will jump out at the sides and escape the pan. Every hopper that gets wet with the oil dies. Many will jump into the oil and jump out to die. When they become abundant in the pan, they should be thrown out.—(Press Bul. 19, Col. Agr. Exp. Sta.)

Rocky-Mountain Locust.—The permanent breeding grounds of this locust extend chiefly along the eastern Rocky-Mountain range, from longitude 102° to 140° west of Greenwich, and from latitude 53° to 40° north, comprising most of the levels below an altitude of 6,000 feet and above 3,000 feet. In many portions of this area they breed every year, and lead an essentially migratory existence. This permanent breeding area gradually shades into a sub-permanent region, in which locusts breed more or less frequently, and which is liable to be invaded at any time or rather whenever the insects become very numerous in their true breeding grounds. This region includes a large portion of British America, nearly all of the Dakotas, Western Nebraska, Northwest Kansas and the northern half of Colorado. Although Minnesota may be said to be located in the temporary region, i. e., a region only periodically visited, yet parts of the state are unpleasantly near the boundary or danger line, and therefore apt to be overrun by hordes of hungry locusts, and such has been frequently the case, as can be seen in former reports. From 1863 to 1878 there was hardly a year in which locusts did not occur in sufficient numbers to injure the crops somewhere. When not occurring elsewhere they were surely found in the Red River Valley. They did not breed there during all these years, but sufficient new swarms came from the northwest to recruit the invading army and make it formidable. In 1877 they destroyed alone in nineteen counties 337,188 acres of wheat.—(Bul. 17, Minn. Agr. Exp. Sta.)

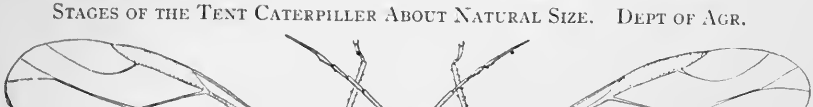
Grasshoppers in Alfalfa Fields.—Of all the insect pests which are found in Nevada the grasshoppers are most destructive, for they injure our most important industries, agriculture and stock raising, by invading the alfalfa fields. They usually do the greatest damage to the second crop of alfalfa, for, though they hatch in spring from eggs laid the previous autumn, the young hoppers do very little apparent injury to the first crop. As soon as it is cut, however, they are deprived of their abundant supply of green food. The few leaves remaining are quickly destroyed, and with them every opening bud and newly-formed leaf. The second crop cannot make a start for the new growth is eaten as fast as it appears. The injured fields sometimes look as bare and brown in midsummer as they are early in spring. In many cases this means the loss of thousands of dollars worth of hay.



Lesser Apple Worm (Enarmonia Pruniora) in Various Stages.
Dept. of Agr.



Stages of the Tent Caterpiller About Natural Size. Dept of Agr.



Corn Root-Aphis (Aphis Maidi Radicis); Winged Female Enlarged.
Dept of Agr.

Every year great numbers of grasshoppers gather along ditch-banks and roadsides and along little-used roads through the fields. In such places as these the females lay their eggs, thrusting the abdomen an inch or more deep in the soil and laying a pod or mass of oblong light yellow eggs. Both sexes die with the coming of winter. The eggs in the frozen soil hatch when the ground grows warm in spring. The young hoppers make their way to the surface and at once begin feeding on the tender green leaves and grass. As the newly-hatched young are small and weak it is a difficult matter for them to make their way to the surface. If the eggs can be buried a few inches in the soil this becomes impossible.

For this reason it is customary in parts of Nebraska and Minnesota to bury the grasshopper eggs by plowing them into the soil. Turned under by the plow the eggs are buried so deeply that when they hatch the young hoppers cannot make their way to the surface. This is a practical and successful way of destroying grasshoppers when it can be applied.

Ditch-banks, roads through the fields, and waste places near the fields, should be examined for eggs late in the autumn. An inch of surface soil in such places should be sliced off with a shovel here and there. If the ground is full of eggs, it should be plowed before winter. The rain and snow will then cake the surface soil and pack it so hard that the newly-hatched grasshoppers can scarcely make their way through. Spring plowing is not so effective because the soil does not have time to settle and pack before the grasshopper eggs begin to hatch.

As vast numbers of these insects hatch out in the fields themselves where plowing is out of the question, harrowing or disking must be resorted to in such situations. Harrowing breaks up the clusters of eggs, buries many of them, crushes some, and scatters the rest through the soil. It is not so effective as plowing because it does not bury the eggs deeply enough to destroy them all. It can be done either in autumn or in the spring.

These methods of destroying the eggs are our most effective means of holding grasshoppers in check. Other methods which are useful in midsummer are discussed in the latter part of this pamphlet, among them poisoning, and the use of hopper-dozers which destroy half-grown grasshoppers by means of kerosene and crude petroleum. Plowing and harrowing are the best methods known. The work should be done early in the winter before the ground is frozen or else as early in spring as is possible.

Grasshoppers in alfalfa fields may be held in check in ordinary years by plowing late in the fall the waste lands where they breed and by disc-harrowing badly infested fields, thus destroying the eggs in the soil. Sometimes, however, the ground is so full of eggs that plowing and harrowing do not destroy enough to prevent great numbers from hatching. In such cases two remedies remain, to be applied just after the first crop has been cut. These are poisoning and the use of hopper-dozers. The Department of Agriculture at Washington, D. C., recommends the following poison mixture:

1 pound paris green.
2 pounds common salt.
60 pounds fresh horse dung.

Mix carefully and thoroughly. The paris green should be mixed with water to form a paste and then stirred into the manure. This mixture can best be made on a small scale in a tub or halfbarrel and distributed with a trowel in the places where young hoppers are thickest. It should be scattered early in the morning while the soil is still wet from the first irrigation. This will help to keep it from drying.

The hopper-dozer is simply a long, shallow pan of stove-pipe iron or galvanized iron mounted on runners and backed by a light frame covered with cloth. The pan is about four inches deep, from eighteen inches to two feet wide, and from ten to sixteen feet long. It is partly filled with water and a little kerosene. A horse drags the machine across the field over the stubble of the first crop and the half-grown hoppers jump into the pan where the oil coats them over and kills every one that it touches. The hopper-dozer works best on level land. On sloping ground the oil and water run to one end and slop over. To prevent this the pan is usually divided into sections by a number of partitions. The runners should stick out in front of the pan about a foot and one-half, and an old piece of chain or heavy rope should be stretched loosely between them to drag ahead of the machine and make the hoppers jump.

In our large fields one such machine is not of much use. Several of them abreast must be driven across the field, for the grasshoppers dodge around the ends of one machine and escape. They cannot dodge three machines abreast so easily. On level fields there are no great practical difficulties in the use of hopper-dozers. Careless driving may spill oil on some alfalfa and kill it. If these machines are to be really effective they must be used before the grasshoppers get their wings. The first crop should be cut as early as possible and the hopper-dozers should follow the rakes as closely as may be. On the whole, they should be used only where plowing and harrowing have not been done or have failed to keep the grasshoppers in check.

The Western Cricket.—The large, black Western Cricket has been very common and destructive in Nevada for several years. It is not a true cricket but a wingless grasshopper. This fact, however, does not affect the purpose of this article for in it we aim merely to discuss means of holding this pest in check. In eastern Nevada, at about the time when the first crop of hay was being cut, the crickets came swarming down from the hills upon the ranches and did a large amount of damage to garden vegetables and to hay and grain. Black and shining, clumsy and repulsive, they come suddenly, without warning, out of the sagebrush and swarm over field and garden, even invading the houses.

They are wingless and crawl upon the ground. They cannot hop over an obstruction a foot high. It would seem very easy to attack them in some effective way and destroy them on an enormous scale; but how? It is clear that we cannot destroy the eggs for these are laid in the ground all the way from the fields to a point half way up the mountains. The young crickets, in bands far up in the hills, are miles away from the ranches, in brush and timber so thick that a horse can scarcely make his way through. It is not probable that any effective warfare can be directed against the young crickets. When the full grown ones come down from the hills, the ranchers are haying. Every one is busy and it is very hard to hire labor of any kind at this time.

Enough has been said to show some of the difficulties in the way of any successful fight against this black pest. Whatever means is used must be fairly cheap, very effective, and must not require any large number of men or any great amount of time to put it into operation.

At present we can take but little practical use of either irrigation ditches, deep trenches or kerosene in fighting the crickets. We have not succeeded in poisoning them in any practical and effective way. Our main reliance at present must be cricket-proof fences of tin or oilcloth. Of these the Nevada tin wall is the most effective. Its usefulness is limited, however, by the small supply of available empty coal oil tins. The oilcloth and burlap fence has not been tested as fully as the other two have been. Our experiments all indicate, however, that it will prove to be a practical method of checking the crickets when it is properly used.—(Nev. E. S. B. 56.)

INSECTS AFFECTING STORED PRODUCTS.

The Angumois Grain Moth.—This insect is one of the most serious pests to stored grain that we have. The moth is thought to be indigenous to the region of the Mediterranean sea. It derives its name from the French Province Angumois, where it was at one time particularly injurious. The food of the Angumois moth in America is quite varied, but corn and wheat suffer most from its ravages.

The adult is a small moth, having a wing expanse of about one-half of an inch. Its body and fore-wings have a soft, shiny, light gray color, while the hind-wings are darker and bordered with a long, delicate fringe. The ventral surface of the body and the wings are darker than the dorsal surface, while the legs are somewhat darker than the body, the caudal pair being hairy, and provided with spurs. The larva is, when full grown, nearly one-fourth of an inch in length, of a light color, provided with numerous hairs, which on the first and last segments are somewhat longer than elsewhere. In general form the body is cylindrical, gradually tapering caudad from the second segment; the head is brown. The egg is somewhat oval in form, and of a pale red color. The pupa is about one-fourth of an inch long, brownish in color, with the abdominal region of a somewhat lighter shade.

The eggs are deposited on the grain, either in the field or in the granary. They are placed in the ears of corn, between the rows of seed, or at their bases under the thin membranes. They may be found either singly or in clusters of twenty to thirty. In the course of a few days the eggs develop into small, active larvæ, which at once eat into the grain, devouring the starchy matter, eventually leaving but a thin empty shell. Two, three, or more larvæ may be found within a single kernel of corn, but the smaller cereals usually afford food for but one. The length of time of the larval stage is usually four or five weeks, although this varies somewhat with the temperature.

When the caterpillar has attained its growth it bores a small hole to the exterior of the kernel to allow of its escape as a moth, and then passes into the pupa state within the seed. The pupa state lasts from a few days to weeks, depending upon the temperature. The entire life cycle from egg to adult is, in this climate, about five weeks. The moths mate soon after emerging from the crysalis, and deposit a laying of eggs. There appears to be no regular time for the appearance of the adults, as all stages may be found at almost any time in the infested grain. This rapid fecundity soon enables them to bring about the destruction of the grain.

Corn that has not been husked is much freer from the attack of this insect than corn that has been husked or shelled. Grain may be badly infested with larvæ and appear to be sound, as the excrement from the larvæ may fill up the small holes through which they entered; but it may be easily detected when grain is infested from its lighter weight. If a few seeds are thrown into water, the infested ones will not sink as will the sound ones.

For the treatment of this and the other insects attacking stored grain considered, see the directions for treatment at the close of this bulletin. Since the treatment for the various grain infesting insects is the same in all cases, it is useless to repeat it for each species.

The Meal Snout-Moth.—The meal snout-moth is well known in Europe where it is a great nuisance. In this country it is gaining quite a foothold, and may ultimately become a serious pest. Like the Indian-meal moth and flour moth the larvæ of this insect make long tubes, by fastening together small particles of food with silken threads which they secrete. In these tubes they live, feed and go through their transformation. The meal moth feeds upon various cereals, and their products. It is said to even attack straw and hay. The general color is light brown. The fore-wings are marked on their basal and distal parts with patches of dark brown. Across each fore-wing are two wavy, whitish lines.

The Mediterranean Flour Moth.—This insect first became noted as a pest in 1877, when it was found to be doing much damage in a flour mill in Germany. From Germany it spread into Holland and Belgium and later appeared in England. In 1889 it appeared in the Dominion of Canada. It is generally distributed over the United States. The adult is a grayish colored moth having a wing expanse of about one inch. The fore-wings are marked with transverse black lines. The hind-wings are of a dirty white color with a darker border.

The larva is worm-like, about one-half inch long. The head is dark brown, and the body provided with bristle-like hairs.

About five weeks are required for this insect to pass through all its stages from the egg to the adult. In the latitude of Washington there may be six or more generations a year. In the Southern States, doubtless more than this may be raised, and it is quite probable that breeding may continue uninterrupted throughout the year. In some places where this insect is known, it has created such havoc that it has been called the scourge of the flour mill. The larvæ live in silken tubes which they spin through the grain or flour, and it is this habit that renders them so injurious. These webs cause a felting together of the flour which clogs the machinery, causing frequent and protracted delays. This caterpillar seems to prefer flour or meal, but it will also attack other cereal products.

The Indian-Meal Moth.—The Indian-meal moth is another serious pest to stored grain and cereal products. It has been bred from flour, dried apples, dried peaches, sweet-corn, field-corn, grits and corn-meal. In the latter it was particularly abundant. Corn-meal set aside for a few weeks becomes badly infested. Besides the above mentioned products which it infests, it is recorded as infesting nuts, condiments, sugars, jellies, yeast-cakes, herbs, roots, millet, all kinds of dried fruits, raisins, prunes, and peanuts. In fact it may be said that almost any kind of edible is subject to its attack.

The adult is a small moth of the family Phycitidæ to which family also belongs the Mediterranean flour moth just referred to. The Indian-meal moth has a wing expanse of about five-eighths of an inch. The basal one-third of the fore-wing is of a dirty white, while the distal portion is reddish brown. The body is rather stout for moths of this group.

The larva, or worm, is a small whitish insect, with brownish yellow head, living within the silken tubes which it spins through the meal, dried fruit, or other material which it may infest. The pupa is a capsule-shaped body about three-eighths of an inch in length. The wing-pads and antennæ are distinctly visible on the ventral surface.

The eggs are laid by the moth in the material on which the larvæ feed. The larvæ spin silken tubes through the food, and in these they live and finally undergo their transformation. Infested meal becomes clotted and lumpy from these silken threads binding the grain together. The life cycle from egg to adult is completed in about one month, which being so short, allows of many generations during the year. This insect probably breeds continuously throughout the year.

The Granary Weevil.—This insect is doubtless native to the Mediterranean region where it probably was known before the Christian era. Having been domesticated for so long a time, it has now lost the use of its wings, which are present only as rudiments, and cannot function for flight. It has been found infesting corn, cowpeas, flour, corn-meal and rice.

The granary weevil is one of the true grain weevils of the family *Calandridæ*. It is a short, stout-bodied beetle, being about one-seventh of an inch long. The thorax is marked with punctures arranged longitudinally. From the head there projects, in front, a long snout-like proboscis, bearing the mandibles, and a pair of elbowed antennæ. The body is hard, and of a uniform chestnut-brown color.

The eggs are deposited singly in the grain. The female punctures the grain with her snout, and in this cavity places an egg. The egg hatches into a very small, white, footless grub, which eats further into the grain, and in which it attains its growth and completes its transformation, emerging as an adult. In the smaller cereals but one larva occupies a single grain. In a grain of corn however, food is found for several. In the Southern States six or more broods are probably raised annually. According to Mr. Chittenden, Assistant Entomologist, United States Department of Agriculture, the time required for the completion of the life cycle from egg to adult in the latitude of Washington is forty-one days. The length of time of the life cycle varies much according to the season and climate. The granary weevil is injurious, both in the larval and adult stages. Flour made from badly infested wheat, according to Dr. Riley, has been the occasion of much suffering, and even death.

The Rice Weevil.—The loss caused by the work of this insect in Florida equals, if it does not exceed that caused by the Angumois grain moth. Together they are responsible for the greater part of the injury done to stored grain. The rice weevil takes this name from the fact that it was first found in rice, but the name is rather misleading, in that it feeds upon many kinds of grain and cereal products. It is doubtless indigenous to India, from where it has become well distributed through commercial relations, to many grain-growing parts of the globe. It was brought to America from Europe, and it now enjoys quite a general distribution in this country where it is to be found in every State and Territory, including Alaska. Its ravages in the North, however, are not so severe as in the South.

The rice weevil bears a close resemblance to the granary weevil, both in size and appearance. It is somewhat smaller, however, and differs from it, in that it is of a dull brown color, and in having the wing-covers marked with a reddish colored spot on each corner. The thorax of this species is densely marked with pits. On the wing-covers the pits are arranged longitudinally. As with the granary weevil the head bears a snout, on which are born elbowed antennæ. The larva, when full grown, is about one-eighth of an inch long, footless and fleshy, being quite similar to the larva of the granary weevil. The pupa is whitish, about an eighth of an inch in length, very much resembling that of the preceding species.

In this State this insect does more damage to corn than to other cereals. It is to be found in the field early in August. But it is when the corn has been gathered and housed, however, that the rice weevil does its greatest damage; here in the warm atmosphere it breeds rapidly, both larvæ and adults sharing in the work of destruction. Eggs are deposited by the female in punctures made in the kernels with their long snouts. But a few days are required for them to hatch into grubs. From three weeks to two months are required for this insect to pass through its life cycle, depending upon the season. Corn infested with this weevil has been reported as injurious to stock when fed and it is not improbable that meal made from infested corn would be seriously injurious to man.

The Bean Weevil.—This bean weevil and the four-spotted weevil are both quite abundant in this State, and are frequently thought to represent but one species. The bean weevil is probably an imported enemy, and has now become quite well distributed over the greater part of the United States. As early as 1860 it was noticed that it was attacking the bean. It is a serious pest to this crop in the field and when harvested. The adult is a small beetle about one-tenth of an inch in length, ashy black, with a slight brownish tinge. The body is quite hard and somewhat flattened. The larva is a small, soft-bodied, grub-like insect, passing its entire life in the bean.

The eggs are placed inside of the pod, the adults gnawing a narrow slit along the ventral suture, through which the ovipositor is thrust and the eggs deposited. No doubt the eggs are sometimes deposited on the outside of the pod, but it is probable that such cases are accidental, and that the eggs are frequently destroyed before hatching. Several eggs may be deposited at one place. In about two weeks these hatch, and the larvæ eat into the beans. Several may occupy one seed, but each having its separate cavity. The germ is rarely injured, it being avoided as if it were distasteful. The larvæ reach maturity in the latter part of the summer, and transform into pupæ in the fall. Some of the beetles emerge in the fall while others do not appear until the following spring, when they deposit eggs again in the young and tender pods. In stored beans the eggs are laid on the outside of the beans, loosely attached. Many successive generations may be raised in stored beans.

The Chinese Cow-Pea Weevil.—This pest has been reported as doing much damage in cow-peas. The adult is about one-eighth of an inch in length and quite robust; the wing covers are reddish brown, mottled, more or less, with a lighter shade, with the prothorax and head darker. It bears a general resemblance to the pea and bean weevils, but the body is stouter.

The Four-Spotted Bean Weevil.—The four-spotted bean weevil is a common and abundant pest in many parts of the Southern States, where it does much damage. The eggs, when deposited on dried cow-peas, are placed on the outside, being firmly glued on by a thin cementing substance, which extends around them somewhat. The small oval eggs may be detected by the unaided eye. Larvæ, after hatching, bore into the peas, and begin to feed and grow. The pupal state is passed within the pea, and from which the adult emerges and deposits eggs for the next brood.

The Pea Weevil.—This small beetle is quite familiar to all as the peabug. It was originally confined to America, but has now become quite well distributed to most parts of the world. The garden pea, which fortunately has not many insect enemies, probably suffers from this insect more than from any other. Its ravages on peas gathered for seed or other purposes, however, may fortunately be prevented.

The adult is a small beetle, about one-fifth of an inch long, rusty black in color, marked with more or less white on the elytra, or wing-covers, and with a whitish spot on the caudal margin of the prothorax. The larva is a short fleshy grub of a yellowish color, with the head black. The eggs are very small, of a deep yellow color, pointed on one end, and quite blunt on the other.

The eggs are deposited by the adult female, indiscriminately on the young pods, soon after they have begun to form. The larvæ hatching eat to the interior and enter the soft peas within, only one grub occupying one pea. The embryo of the pea is rarely destroyed by the grub, but the plant resulting from its germination will be feeble, and dwarfed. When the larvæ attain their growth and are ready for transformation, they eat a round hole outward to the shell of the pea, to allow for their exit as adults, and then pass into the pupa state. Adults may emerge in the fall or in the spring.

The result of using weevily peas for seed should be noted. Weevily peas before stated are not able to produce strong, healthy vines from the fact that the stored up nourishment for the plantlet in its early growth has been destroyed, and it is hence unable to get a strong vigorous start in the soil. It is quite important therefore, that peas selected for seed should be free from weevils.

The Slender-Horned Flour Beetle.—The slender-horned flour beetle is quite generally distributed over the Southern States where it is destructive, feeding upon grain, both in field and when gathered. It is also destructive to cereal products. This insect is doubtless indigenous to tropical America. Its northern limit is probably in the region of the Ohio River.

The beetle is a small insect, a little more than one-eighth of an inch in length, bearing much resemblance to the confused Flour Beetle, except that it is somewhat smaller, and lighter in color. On the head are two pointed protuberences. The larva is also much like the larva of the confused Flour Beetle. The habits are essentially the same. The habits and life history of this insect is for all practical purposes the same as those of the confused flour beetle.

The Confused Flour Beetle.—This beetle is minute, elongated, reddish colored. Eggs are laid in flour or other material infested, which hatch into small inconspicuous larvæ. In the due course of time the adults appear and eggs for another brood are laid. These insects increase with considerable rapidity, and soon bring about a loss to the infested substances. They impart to the infested material a persistent and disagreeable odor.

The Rust-Red Flour Beetle.—This insect is well known in Europe as a grain and flour pest. Dr. Hagen records it as also quite injurious to the collection of insects in the Museum at Cambridge. In the United States it seems not to have attracted much attention by entomological writers until the last few years. It seems now to be on the increase, and has already become a pest of no little significance. This insect is quite abundant, doing much damage to all forms of cereal produce, corn, cotton-seed, peanuts, dried fruits, and like substances. It attacks the herbarium specimens, bird-skins, and insect collection. To the latter it does most damage; presence in the specimens is indicated by the accumulation of dust beneath, on the bottom of the box. If an infested specimen be examined it will be found to be perforated with small holes which these pests have made. They feed upon the dried tissues within where their larval and pupal stages are passed.

Unless an insect case is exceedingly tight they find their way inside, their flat bodies enabling them to pass through very small cracks. Frequent inspections of the collections, and fumigation with carbon bi-sulphide is the means employed in keeping them in check.

The adult is a small beetle of a rust-red color, being a little more than an eighth of an inch in length. The body is greatly flattened, and is elongated. The larva is about one-fourth of an inch in length, and is quite active. It is of a whitish color, provided with three pairs of legs, and with numerous hair-like bristles distributed over the body.

Eggs are deposited by the adult females, in the food upon which they feed. These hatch into minute, pale colored larvæ which when in flour, meal, and similar products are rarely detected on account of their small size. These grow into full-sized larvæ which pupate and give origin to the adult beetles. The entire life cycle requires probably from thirty-five to forty days. In this climate it is quite probable that they breed throughout the year. This insect will attack corn while yet in the field, doing damage before the corn becomes hard.

The Red Grain Beetle.—This small red beetle is a pest of considerable importance in the Southern States. It attacks corn, peas, and the cotton-bolls of the cotton-plant in the field, and will continue breeding in corn after it has been gathered. Specimens of this insect were also found infesting bird-skins in the college collection.

The adult is a small, flat, reddish beetle, measuring one-tenth of an inch in length. The larva when full grown is about the same length as the adult. It has a somewhat flattened body, of a whitish yellow color, with the head brownish. The eggs, which are laid at the base of the grains of corn, soon hatch into small larvæ which at once eat into the grain. In the course of three weeks the larvæ become full grown, and transform into pupæ. This state lasts about two weeks, when the adults appear. These insects are very prolific and in infested corn stored away in the fall, they soon become quite numerous. It is probable that eight or ten generations are reared annually, and in some portions breeding is probably continuous.

The Corn Silvanus.—The saw-toothed grain beetle is a small insect of the family *Cucujidae.* The majority of the insects of this family live under bark and are carnivorous both in the larval and adult stages. The corn Silvanus, and some others of this family, however, feed upon grain. The corn silvanus is to be found over almost the entire globe, infesting granaries, barns, dwelling houses, grocery stores, and in fact almost any place where it may find food. It is very common in flour, meal, corn, dried fruits, rice, and bread. It is a common pest in the museum specimens here at the Station, and with the rust-red flour beetle is responsible for much of the damage done to the entomological collection.

The adult Silvanus is only about one-tenth of an inch in length, with a slender, much flattened body of a chocolate brown color. The thorax on each side is provided with six teeth-like projections, while the upper surface has two shallow longtitudinal grooves. The larva is a yellowish white, worm-like insect about one-fourth of an inch in length, provided with three pairs of well developed legs. It is exceedingly active, readily passing from one seed to another for food. The pupa is a little shorter than the beetle, of a yellowish white color, and has spinous processes on both sides of the thorax and abdomen.

The life cycle in this climate requires about four weeks; it is thus readily seen that there may be many generations during the year. The eggs deposited among the grain soon hatch and the active larvæ begin to feed. When ready to pupate the larva constructs a protecting case by jointing together bits of trash and food material with a silken secretion. In this case the pupal state is passed, and from which the adult beetle emerges later on. Unlike the Angumois grain moth the adult of this insect feeds upon the grain with the larva.

The Grain-Eating Brachytarsus.—This is an insect that has not heretofore been recorded as injurious to stored grain. The larvæ of the genus *Brachytarsus* have been supposed to be parasitic on scale insects, but this species has been found feeding, both in the larval and adult condition, on stored corn, cow-peas and English peas, and doing serious damage. The English name of grain-eating Brachytarsus has, therefore, been given to this species, indicating its grain-eating habits. Many of the species of the family to which this insect belongs, infest seeds, and the stems of plants, in their larval state; it is not the cause of much surprise therefore, to find this species of snout beetle feeding upon various seeds.

The adult is quite a thick bodied insect of an ashy brown color, and densely hairy. The wing-covers are marked with punctured lines, and a series of gray and black spots. These spots are due to the presence or absence of the light colored hairs. It is about one-fifth of an inch long.

The pupa is about five thirty-seconds of an inch in length, whitish, and densely covered with short spine like protuberances. Rather long hairs are sparsely distributed over the body. The head is bent down on the ventral surface of the prothorax. Each wing-cover is marked with two pairs of rather prominent lines, the lines of each pair curving in and meeting each other at the distal extremity of the wing-cover.

The larva measures about three-sixteenths of an inch in length, is whitish in color, and footless. The body is quite robust, subcylindrical in shape, somewhat flattened on the ventral surface. The caudal end is rather bluntly rounded, the cephalic end tapering slightly from about the third segment. Labrum and mandibles yellow, the tips of the mandibles being almost black. The body is quite thickly covered with hairs.

A single larva only occupies the interior of a kernel of corn, eating out a broad cavity from the base to the opposite end of the kernel, where it is usually enlarged, and a small portion eaten out to the hull before pupating. It would seem that the larva enters the kernel at its base where it may be more easily penetrated. An infested grain usually appears quite sound exteriorly until the pupal stage is reached when the cavity may be detected through the thin hull. The adult escapes by gnawing through the thin membrane to the exterior. Immediately after coming from the pupa state the adults are reddish brown, not acquiring their final color and activity for two or three days. Older specimens liberated from their cavities immediately took flight; they are surprisingly quick in the use of their wings, and thus frequently escape.

Adults kept in confinement fed readily on cow-peas and corn, showing no preference to any part of the seed. Eggs have not as yet been discovered, nor has the manner of oviposition been observed. Experiments indicate that under favorable conditions the life cycle may be completed in five or six weeks. Breeding continues as late as November and probably throughout the winter.

The Catorama Flour Beetle.—This small beetle which may be called the Catorama flour beetle, is an insect of considerable abundance in corn, corn-meal, and flour. It is also quite destructive to museum specimens, particularly bird-skins and insects. It belongs to the *Ptinidæ,* a family of small beetles, which feed mostly upon vegetable matter in an incipient stage of decay. The beetle is about one-eighth of an inch long, body rather elongate, the head being strongly deflexed, and when in repose bent up on the under surface of the prothorax. The beetle is of a dark brown color, quite densely and uniformly covered with light yellowish colored hairs.

Treatment.—Many different substances have been recommended at various times for the destruction of insects injurious to stored grain. Some of these are of value in a greater or less degree. Others are quite worthless. Certain preventive measures that are in practice in the South seem to be of some value. Most farmers in Florida do not husk their corn when harvested as the husks offer considerable protection against lepidopterous insects, and weevils. It is also a common practice to gather the corn and leave it in heaps in the field for a few days to allow the ants to destroy the larvæ that infest it. Others leave an open space in the roof of the crib so that rain may enter and thoroughly wet the corn, bringing about a period of heat that is said to destroy the infesting weevils and larvæ, doing no harm to the corn. It is a rather prevalent idea that certain varieties of grain are weevil proof, and inquiry is sometimes made for definite information on this subject. It should be known that there is no variety of grain that is weevil proof. However, the condition in which the grain is kept is of some importance. In general, unhusked grain is much freer from attack than grain that has been husked. Corn is much more subject to attack when shelled than when left on the cob. Those varieties of corn that have hard, flinty kernels and close fitting husks are not so subject to attack as other varieties. But it is hardly profitable to discuss these various preventive measures as we have in carbon bi-sulphide, a remedy that is effective, cheap, and simple in its application. Its use is yearly becoming much more general. Carbon bi-sulphide is a chemical compound of the formula $C. S_2$; as the name and symbol indicate, it is bisulphide of carbon. It is a colorless liquid, having a very strong, disagreeable odor, and is quite volatile, vaporizing at an ordinary temperature. It is also highly inflamable, and hence in its use care should always be taken that no fire of any kind be brought near it. A lighted match, lighted pipe or lighted cigar should not, under any circumstances, be brought near a building that is being fumigated. The fumes of this compound are very poisonous. Therein lies its value as a destructive agent against insects. The deadly fumes of this compound enters their breathing tubes with the air which they breathe and quickly brings about their death. The fumes are also poisonous to other animals, but there is little danger to man from inhaling a small quantity.

The application of carbon bi-sulphide is but a process of fumigation, and in order that the fumes may be kept within the bin or crib they should be as tight as possible. If they are not tight much more of the compound will be required. Bins may be made much tighter by covering them as much as possible with cloths and blankets. Oil cloth and heavy canvas are excellent. In a moderately tight bin one pound of the sulphide should effectually fumigate one hundred bushels of grain. Several methods are in use for the application of the sulphide. A ball of cotton tied to a stick may be saturated with the compound and pushed down to near the center of the grain. By doing this, it is believed that the air becomes more evenly saturated with the sulphide. Another method consists in pushing a long pipe, in which is a tight fitting rod, down into the grain. The rod is withdrawn and the carbon bi-sulphide poured into the tube. But the most effective way of applying the compound, when the bins are moderately tight, is to pour the reagent in shallow dishes or pans which may be placed here and there on the top of the grain. The compound being volatile rapidly vaporizes, and being heavier than air, sinks and becomes thoroughly diffused throughout the bin. Balls of cotton or waste may be saturated with the sulphide and distributed over the surface of the grain. In case all the insects are not destroyed by one application, another should be made. Grain treated with the sulphide is not injured for food purposes, or for seed. To secure the very best results from the use of carbon bi-sulphide a tight quarantine bin should be made, somewhat separated from the other buildings, where the grain may be subjected to a thorough fumigation before being stored away. Here the insects that have gotten into the grain while in the field will all be destroyed, thus removing a serious source of infection to the stored grain. Before a crib is to receive the harvested and fumigated grain, it should be thoroughly fumigated and cleaned. All cracks, loose fittings, and holes should be stopped up as well as possible.

Grain having been fumigated and placed in a tight crib or bin that has been cleaned will suffer but very little from the ravages of insects during the year. Should they become troublesome at any time another application of the sulphide should be made. Peas, rice, shelled-corn and other seeds are frequently stored in barrels or boxes. These may be easily fumigated by saturating a piece of cotton with four or five ounces of carbon bi-sulphide and placing it on top of the seed, throwing a heavy cloth over the top of the barrel to keep the fumes within. It should be noted that the treatment given above, is for grain that has been husked or hulled. Where the grain is not husked a somewhat larger quantity of the bi-sulphide will be needed.

The protection afforded by the husks against grain insects is far less than the advantages gained by having it husked so that it may be the more thoroughly subjected to the fumes of the insecticide. It is therefore recommended that corn be husked when harvested, and carbon bi-sulphide be used to keep it free from weevils and other insects.

Carbon bi-sulphide may be purchased at drug-stores for twenty to thirty cents per pound. Arrangements might be made with local druggists, who would order carbon bi-sulphide in fifty pound cans, or larger lots, and who could then afford to sell it much cheaper than the usual retail price.

Hydrocyanic acid gas, sulphur fumes and heat may be successfully employed as outlined in the chapter on fumigation.—(Fla. E. S. B. 36.)

*The Sugar-Cane Leafhopper.**—Leafhopper is a popular term applied to a certain group of plant-feeding insects of the order Hemiptera. Common characteristics of these insects are their peculiar habit of springing or jumping when disturbed; their feeding upon plants by sucking from the tissue the plant juice or sap through a beak or proboscis, a piercing organ by means of which they puncture the epidermal layer of the plant; their incomplete development (that is, the young upon hatching from the eggs resembles the adult, except that it is smaller in size, wingless, and sexually immature and by a gradual process of development acquires the characteristics of the adult); and the fact that their eggs are deposited in the same plant upon which the young and adult appear and feed.

The eggs of the sugar-cane leafhopper are deposited beneath the epidermis of the cane plant in situations along the midrib of the leaves, in the internodes of the stalk, or, in the case of young unstripped cane, in the leaf sheath of the lower leaves. As the growth of

*The sugar cane insects of Louisiana and the other Southern States are identical with the Hawaiian sugar cane pests.

the cane continues and the new leaves unfold toward the top of the plant, the infested leaves naturally occupy the lower position on the stalk. The leafhopper, during a heavy infestation, will continue to puncture the midribs of the leaves as rapidly as the leaves unfold. The eggs deposited in cane growing in rearing cages hatch two weeks thereafter. The period of development of the young to the adult requires 34 additional days, making the life cycle 48 days in length.

The fact that the eggs will hatch from cane cuttings during a period of at least 38 days is a very important point to bear in mind in the shipping of infested cane from one locality or country to another. On issuing from the cavity, or chamber, the young, newly hatched leafhoppers appear at first small, slim, wingless nymphs, almost transparent. They are at once active and scatter over the plant to feed, congregating at first down within the sheaths of the upper leaves. In a few hours the body becomes shortened and the outer covering, on exposure to the air, becomes darker in color. The habit of the very young in secluding themselves within the lower sheaths of the leaves renders them quite inconspicuous unless especially sought for.

The presence of the pests on the plantations was noticed first by the appearance of a sooty black covering on the lower leaves of the cane plant. This black covering became known as smut. It is a fungous growth and finds a medium for development in the transparent, sticky fluid secreted by the leafhoppers during their feeding on the plant. This secretion is commonly known as honeydew. The black smut or fungous growth in the honeydew secretion of the leafhopper and the red discoloration about the openings to the egg chambers in the midribs of the leaves are the most pronounced symptoms of the work of the leafhopper on cane.

In the case of heavy infestation a further result is the appearance of the plant as a whole. The leaves on which the insects have been feeding develop a yellowish appearance, and as the work of the insects progresses they become dried and resemble the fully matured lower leaves of the plant. This premature death of the leaves is due to the excessive amount of juice extracted for food. As long as the cane plant is able to produce new leaves its life is not actually in danger, the injury being a check to the growth and indicated by the small, shortened joints in the stalk. Leaves thus prematurely ripened do not drop away from the stalk at the junction of the sheath, as is the case under normal conditions, but break and hang down at the junction of the leaf to the sheath, leaving the sheath still wrapped about the stalk. Leaves in such a condition remain green for some time, attached to the sheath by the midrib, and an attempt to strip the cane results in leaving the sheaths still adhering to the stalk and wrapped about it.

In the last stages of an attack, when the plant is actually overcome by the pest, the young unfolded leaves at the top do not appear to have the vitality to unfold and the bud gradually dies out. At this stage the normal growth of the plant ceases. Many plants in such a condition will then throw out sprouts from the eyes. This is a serious circumstance, since the growth of the sprouts is supported by the stalk, and unless the cane is soon cut and ground the stalk is rendered worthless.

The first injury to the cane plant by the leafhopper occurs through the piercing of the epidermal layer by the ovipositor. Through these wounds various diseases may also gain entrance to the tissues of the plant, carried thereto by the leafhoppers themselves in flying from infested to noninfested plants, or by other insects, particularly certain flies, which frequent the cane plant. The most serious injury to the plant is the drain upon its vitality caused by the young leafhoppers in feeding. The thorough burning of the trash after the cane is harvested is the most effective method practiced for the control of the insects of sugar cane. In the case of the leafhopper many of the adults no doubt take flight, but the destruction to the eggs and immature forms in the trash is enormous. Both for the leafhopper and the cane borer, burning off has become general once more. Rotation of crops will be of great benefit.

The Hawaiian Sugar-Cane Borer.—The sugar-cane borer infesting the cane stalk in Hawaii is the grub of a beetle belonging to the weevil family *Calandridæ.* The sugar-cane stalk-borer of the southern United States is the caterpillar of a moth. Entomologically the two species are widely separated, belonging to entirely different orders of insects, but in the character of their injury to the cane stalk these two insects are quite similar—that is, they both develop within the cane stalk, and by feeding on the interior cause great destruction to the plant. Comparatively, the Hawaiian borer is more destructive and, because of the habits of the adult, a more persistent species to combat. The adult beetle of the Hawaiian borer is a stronger flyer than the adult moth of the mainland borer and therefore has a wider range over any infested territory. As the adult of the Hawaiian borer, too, can emerge from any reasonable depth when buried in the soil, this renders the question of infested seed cane a serious one in Hawaii, while on the mainland the careful covering of infested seed cane is effective in preventing the emergence of the adult moth. These points are mentioned to bring out the fact that we are discussing here a species in no way related to the cane borer of the Southern States and in many ways not subject to the same means of control.

The eggs are found beneath the epidermis of the cane stalk, or more rarely in the tissue of the leaf sheath, having been placed singly in small cavities. The cavity is made by the female with her proboscis before depositing the egg. The young grub or larva, on hatching from the egg, bores on into the stalk of the cane, completely honeycombing the interior with tunnels running lengthwise with the stalk. The evidence of its work is not indicated by the outward appearance of the stalk. Many times a stalk, seemingly in a normal condition, is found on examination to be utterly destroyed. The life of the borer within the stalk of the cane is estimated to be about seven weeks by Mr. Koebele, who points out the fact that the length of the larval life depends to a great extent upon the condition of the food plant and climatic conditions; that is, the development will be more rapid in softer cane and during the warm summer months than during the low temperatures of winter.

When ready to pupate—that is, to transform to the inactive stage preparatory to emerging from the stalk as an adult beetle—the larva forms about itself a cocoon from the fiber of the stalk within the tunnels it has made in feeding. The adult beetle on issuing from this cocoon bores its way through the side of the stalk to the exterior, and this opening in the lower joints of the cane is the first distinct symptom of the presence of the borer. The length of the pupal period is as variable as that of the larval, the average time for transformation and emergence being from two to three weeks.

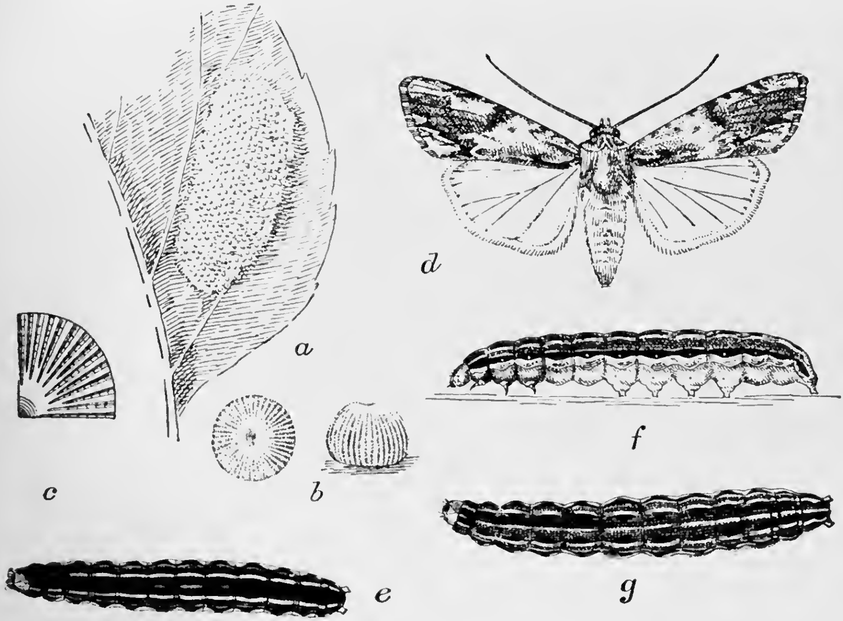
The beetles are night flying and hide during the day down within the sheaths of the lower leaves. The softer varieties of cane are more subject to attack than the hardier varieties, and the borer is more abundant in the wet districts than in the dry. Cane which has received an abundant supply of water by irrigation suffers more from the work of the borer than unirrigated cane. The borers occur in the largest numbers in young cane and the suckers are infested to a much greater degree than the stalks. The borers always occur in the largest numbers in the vicinity of the track used to haul cane to the factory, issuing from infested stalks that have dropped from the cars and have not been collected and destroyed afterwards.

The borer is a strong flyer and spreads from field to field in this manner. It is distributed in infested seed cane and also develops from the stalks left in the field after harvest or dropped from the wagons or cars in hauling to the factory.

As has been mentioned, the softer varieties are more subject to attack than the hardier ones. The Yellow Caledonia, a variety which is replacing to a great extent the common Lahaina and Rose Bamboo in Hawaii, is injured to a much less extent than other varieties. The infestation is not necessarily less in Yellow Caledonia, but the borer meets with greater resistance in its feeding and consequent development because of the firmness of the fiber.

Excessive irrigation favors the development of the pest, since cane in a succulent condition is more easily infested by the borer and its development within the stalk is more rapid. It is plain that in fields heavily infested by the borer the minimum amount of water should be used in irrigation.

The burning of trash after harvesting the cane is the most effectual method of keeping the borer in check. In this practice not only should the fields be burned over, but all the unburned stalks left in the fields and all stalks dropped from carts and cars along the roads and tracks used in hauling the cane to the factory should be collected and burned. One plantation found it necessary to collect such stalks in piles and use crude oil on them in order to destroy them completely, and by a careful estimate of the labor and cost of material found that the money had been well invested, as was shown by the reduction in the numbers of borers in the fields the following season.



SEMI-TROPICAL ARMY WORM IN STAGES. DEPT. OF AGR.

APPLYING PARIS GREEN TO TOBACCO WITH A DUST GUN. DEPT. OF AGR.

The Hawaiian sugar-cane borer is able to emerge to the surface from any reasonable depth when planted with seed cane. For this reason great care should be exercised in the selection of cane for planting purposes, since new areas can in this way be readily stocked with the pest. It is not practical to treat successfully cane infested with the borer, since the borer is fully protected within the stalk. Therefore, next in importance to the thorough burning of all trash after harvest is the selection of noninfested seed cane.

The most effective direct measure employed against the cane borer is the collecting of the adults during the daytime from their hiding place within the lower leaf sheaths. The supply of labor will influence the ability to use this method. The method is more feasible where the plantation is so situated that women and children can be employed for the work. Care should be exercised in this work in order that the growing leaves may not be broken down. It is obvious that a larger number of beetles will be collected when the wages are based on the numbers collected, but the results are more satisfactory, as regards breaking down the cane, when the wages of the laborers are fixed at a certain amount per day. In the Fiji Islands a method of baiting the beetles is employed, which consists of splitting cane stalks and placing pieces about the edges of the field and within the rows at certain intervals.

An important point regarding this split cane is that the females usually infest these pieces heavily with eggs and the young resulting grubs bore into the split stalks and perish as the pieces of cane become dry. In dry localities the pieces of split cane should be placed in the irrigation ditches during the day and placed out as a bait in the evening, otherwise they dry out rapidly and cease to attract the beetles.

The Hawaiian Sugar-Cane Leaf-Roller.—During the investigations relating to the leafhopper in 1903 the writer found the Hawaiian sugar-cane leaf-roller, the caterpillar of a native moth, doing serious damage to cane. On sugar cane the very young larvæ feed in the crown of the plant where the young leaves have not yet unrolled. They are thus protected between the natural rolls of the leaf; later on they roll over the margin of a leaf forming a tube for their retreat. When nearly full grown, they are usually found in tubes towards the tip of the upper leaves. These tubes are easily observed if the ragged leaves where the larvæ have fed, are examined. The work of the smaller larvæ shows as oval or elongate dead spots on leaves which have unrolled in the growing of the cane after the young larvæ have fed upon them.

When disturbed in its retreat, as by its being torn open, or violently shaken, or jarred, the larva wriggles very lively and drops to the ground for escape. This habit is probably to escape from parasites, many of which prey upon them. The retreat which it constructs is undoubtedly for the same purpose, as well as for protection from wasps and birds which prey upon it. The caterpillars are full grown in about three weeks from hatching. They molt five times at intervals of about three to five days, and five to seven days between the fifth molt and the spinning of the cocoon and pupation. Pupation takes place within a slight cocoon of white silk in the "retreat" where the caterpillar has lived, however, the cocoon is sometimes made beneath the leaf-sheaths of cane, and in other favorable places.

No special remedies are employed in cane fields against this pest. Swezey suggests that in fields of young cane a spray of Paris green or arsenate of lead might be used with effect, and mentions that at times laborers have been sent over the field to pinch the caterpillars in their retreat between the folded cane leaves.

The Sugar-Cane Mealy-Bug.—This insect is identical with the sugar-cane mealy-bug common on cane in the southern parishes of Louisiana. The mealy-bug of the cane belongs to a very large family of insects, Coccidæ, which are world-wide in their distribution. In Louisiana the mealy-bug infests, aside from sugar cane, the Johnson grass (*Sorghum halepense*) and the saccharine sorghums.

The feeding habits of the mealy-bug are similar to those of the cane leafhopper; that is, their mouthparts are formed for piercing the epidermis of the plant and sucking the plant sap from the inner tissues. The distinction in the feeding habit is that the leafhopper is active throughout its entire life cycle, and jumps or flies from plant to plant, while the mealy-bug when partly grown remains practically stationary and feeds upon but one portion of the same plant.

Where the cane mealy-bugs occur in Hawaii, they can be found about the lower leaves of the cane, congregating for the most part behind the older leaves near the ground. The species may be recognized by the white mealylike covering of the adult female, to which the common name applies. The insects occur in a mass and when abundant are readily observable by the white covering of the females. This white covering serves as a receptacle for the eggs, which, upon close examination, may be observed embedded therein.

In Louisiana the insects occur not only about the lower leaves of the plant, but are to be found also around the crown and beneath the surface of the ground about the roots of the plant. In this latter location they hibernate during the cold months of winter on both cane and Johnson grass.

The young mealy-bugs upon hatching from the eggs are quite active and disperse over the cane plants, finally congregating when partly grown about the lower nodes of the stalk. The females are practically inactive, remaining in a mass about one of the nodes or beneath the leaves throughout their development and secreting about themselves in these locations the characteristic white covering. The young males do not remain stationary on the plant, but, after completing their development, spin a narrow white cocoon within which they transform to a delicate winged adult.

Since the common method of distribution is by the transportation of infested seed cane from plantation to plantation or from one part to another of the same plantation, care should be exercised to select clean stalks and not those which are infested, for seed cane. The practice of burning the trash after harvest is very effective in destroying this insect, since those remaining on the stalks are killed in the process of milling, and the remaining forms on the discarded stalks and leaves in the field are destroyed by the fire.

Miscellaneous Insects Affecting Sugar Cane in Hawaii.—An aphis is occasionally injurious to sugar cane. In some districts where the cane fields are situated in moist locations, a mole cricket is sometimes abundant enough to be injurious. Another species of mole cricket is a most important pest of sugar cane in the island of Porto Rico. Regarding the work of the Hawaiian mole cricket, Prof. Koebele reports as follows:

A species of mole cricket has appeared in very large numbers in some of the moist valleys on Oahu. It is likely another Asiatic introduction. As a rule these crickets are found around the muddy borders of shallow ponds and watercourses where they live in burrows resembling those of moles, and, like that animal, their food consists chiefly of earth worms and the larva of various insects. The opinions as to its habits are as yet divided; whilst some authorities claim that it is beneficial, others place it amongst the injurious insects. Specimens kept in confinement here with pieces of sugar cane would hardly touch them, yet they readily devoured a large number of the larva of the Adoretus or Japanese beetle, as well as those aphodius and a number of earth worms, all within 24 hours.

The ground infested by these crickets was examined and found to be very wet and completely riddled with the burrows down to a depth of three and even four feet. As many as three and four specimens were brought to light in a single shovel full of the soil. In such localities there is no question as to the injurious effects of the crickets on young cane plants, wherever they were numerous almost all of the seed cane was destroyed; they would burrow into the seed from all sides, destroying all the eyes; where the plants had made a growth of a couple of feet the cricket would burrow in below the ground and eat to the center, killing the plant. This is the only instance so far observed of the depredations of these crickets here. In rice and taro fields no damage has been observed as yet, and the only damage that is likely to occur to cane is when it is planted in wet swampy land, as the cricket can only live and thrive in such places, and is not found in ordinary arable land; even in the swamp where the cricket was very numerous, it did not attack the old cane but paid its attention solely to the newly planted seed and very young plants.

This cricket although living in marshy land, cannot live under water, yet it is a good swimmer; the only remedy that can be recommended at present is to flood the land with water and collect the crickets as they come to the surface, destroying them by placing them in a vessel containing kerosene and water. The fungoid so contagious to many insects and larva here, does not seem to have any effect on this lively cricket, nor will he have anything to do with poison given in the style of bran, sugar and arsenic. Certain army worms and cutworms are occasionally known to strip fields of young cane.

A bud moth is found generally throughout the Hawaiian cane fields and at times is quite numerous.

It is usually not particularly injurious as it customarily feeds on the dead and drying tissues of the leaf-sheaths of sugar cane; but when very numerous and on particularly soft varieties of cane the caterpillars do considerable eating of the epidermis, and also eat into the buds and destroy them, occasioning a good deal of loss where the cane is desired for cuttings to plant.

The grasshoppers feed to some extent on the leaves of cane. Two species of beetles which occasionally invade the cane fields from their common food plants and attack the leaves of the sugar cane are Fuller's rose beetle.

Rats Injuring Growing Sugar Cane in Hawaii.—The so-called roof-rat in former years was very common in the cane fields of Hawaii and did considerable damage by eating the stalks. This is also the cane-field rat of the island of Jamaica. The species in Hawaii lives now for the most part in trees and the upper stories of dwellings, since it has been driven to a great degree from the cane fields by the introduced mongoose. The introduction of the mongoose was a benefit as regards its destruction to the rats in the cane fields, but the animal is an undesirable acquisition to the fauna of the islands for the reason that in recent years it has included in its dietary the eggs and young of ground nesting birds and domestic fowls. The destruction of the ground-nesting birds is most regrettable.

INSECTS AFFECTING THE COTTON PLANT.

The Cotton Worm, or Cotton Caterpillar.—This insect is perfectly familiar to all cotton growers. The slender, bluish-green caterpillar with small black spots, and often with black stripes down its back, which loops when it walks and feeds voraciously on both upper and under surfaces of the cotton leaf, is to be found in cotton fields in the Gulf States all through the summer. It is generally not noticed in the early part of the season on account of its insignificant numbers. Later, through the ragging of the leaves, it becomes noticeable, and in seasons of abundance the plant is entirely defoliated. Farther north the insect makes its appearance at a later date in the season, and there the caterpillars are not the offspring of hibernating moths, but of the moths of the first or second generation, which have developed in more southern cotton fields and have flown north with the prevailing southern winds. Late in the season moths of the fourth or fifth generation fly far to the north, frequently making their appearance in numbers about electric lights in Canada. There is no absolute evidence of any other food plant than cotton, although many entomologists have surmised that the species has a northern food plant. The specimens seen in Canada have, however, in all probability flown north from cotton fields in the Carolinas, and perhaps even farther south.—(Farmers' Bul. 47, U. S. D. A.)

After hatching from the egg, the young larva feeds at first upon the under side of the leaf, devouring simply the lower parenchyma and not piercing through to the upper side until after the first molt. At first the larva is pale yellow in color, soon becoming greenish. The dark spots become more or less conspicuous after the first molt, and the characteristic markings make their first appearance. After the second molt these markings become more conspicuous, and the insect takes on a distinctly greenish color, the black along the back varying among different individuals in its intensity. Before reaching full growth the caterpillar sheds its skin five times, and the duration of the caterpillar stage is from one to three weeks. Early in the season the green color appears to predominate, while toward the fall the blackish caterpillars are more abundant, although at any time during the season green and dark worms are seen together. Although the normal food of the caterpillar is the leaves, it will frequently gnaw the tender twigs and will even damage the bolls by eating into them in spots. This, however, generally occurs only when the worms are present in exceptional numbers and the supply of leaves becomes exhausted.

The caterpillar, having become full grown, never enters the ground to transform, although many planters have believed that this is the manner in which the insect passes the winter. It spins a slight silken web, forming an imperfect cocoon, usually within a folded leaf. It is frequently seen hanging quite naked upon the plant, but in such cases the leaf in which it was originally spun has been eaten away by other caterpillars. Its color is at first green, but in the course of an hour or so it changes to brown. The insect remains in this condition for a period varying from one week to thirty days.

The perfect insect of the cotton caterpillar is a rather small moth of an olive-gray color, sometimes with a somewhat purplish luster. Its wings expand from 1⅛ to 1½ inches. The moth is a night flyer and hides during the day, starting up and flying with a swift, somewhat darting motion when disturbed. After sunset it takes wing and flies about, laying its eggs or searching for food. It feeds, in fact, rather extensively, frequenting neighboring flowering plants and also the nectar glands of the leaves of cotton. Fruit, as it ripens, also attracts these moths, and is frequently seriously injured by them. The female begins to lay her eggs in from two to four days after leaving the chrysalis, and each individual lays from 300 to 600 eggs. With five consecutive and rapidly developed generations the occasionally extraordinary numbers of the late broods are not to be wondered at.

The importance of ascertaining the early presence of the worms, although in small numbers, from a remedial point of view, is very great, and since it was conclusively shown that worms may be found in the fields in the Gulf States long before the so-called "first-crop," planters have looked for them more carefully, and doubtless in many cases possibly severe injury has been prevented by the poisoning of early worms.

The greatest difficulty was found in settling the question as to the manner in which this insect passes the winter, but it has finally been established that over the more northern portion of the cotton belt the species dies out every year, while in the more southern portions the moth hibernates and remains torpid in sheltered situations.

The Cotton Bollworm.—Unlike the cotton worm, this insect is by no means confined to America, nor is it confined to cotton as a food plant. It is known in many other parts of the world, and it can not be surmised at the present time whether it has been carried from some one point or whether it is indigenous over its extremely wide range. Its food plants vary in an extraordinary degree. In this country it is one of the principal enemies of cotton, of corn, and of the tomato.

The cotton bollworm, the corn earworm, and the tomato fruit worm are all the same species. In addition to these crops, it feeds upon peas and beans, tobacco, pumpkin, squash, okra, and a number of garden flowering plants, such as cultivated geraniums, gladiolus, mignonette, as well as a number of wild plants.

"Undoubtedly for several years the boll weevil has caused a loss of about 400,000 bales of cotton annually. Although farmers in older regions, in many cases, are increasing their production, there is loss in the newly infested regions which offsets that gain. A conservative estimate shows that since the weevil has invaded this country it has caused a loss of 2,550,000 bales of cotton, at a value of about $125,000,000."—(Farmers' Bul. 344 U. S. D. A.)

When first hatched, the bollworm looks much like the cotton worm. It is rather darker in color, but also walks like a looper, or measuring worm. It feeds at first near the eggshell, and then begins to wander away, crawling from one leaf to another, until a young bud or boll is found, into which it bores. Frequently several days pass in this search for a boll, and rarely the worm may reach full growth upon a diet of leaves. It is during this early, wandering leaf-feeding existence that the insect may be destroyed by arsenical poisons, as is true of the cotton worm. When the young worm enters the flower bud the involucre flares open and the young bud or young boll finally drops. This "shedding" of cotton is, however, not caused by the bollworm alone. Other insects are concerned in the damage, and the flaring and dropping occasionally occurs when no insect injury can be found. A very considerable amount of damage may be done in this way, as a single young larva will travel from bud to bud, deserting each before it falls. The bud pierced just before opening is forced into premature bloom, but the worm usually feeds upon the stamens and pistil, rendering it incapable of fructifying. As the bollworms grow, they begin to vary greatly in general appearance. Full grown worms may be found of almost every intermediate stage of color between light green and dark brown or rose. They may be unstriped and unspotted, or they may possess dark stripes or black spots. These color varieties are not caused by different food, since many variations occur in specimens feeding upon the same plant. Upon cotton the larger worms take the larger bolls, the young ones having confined themselves in the main to the flower buds and the newly formed bolls. They then practically progress downward, the young ones being found mainly upon the top crop, while the older ones bore into the older bolls of the middle crop, the bottom crop being seldom seriously damaged by this insect. Often a single worm will practically destroy several large bolls, and one instance is on record where 18 young bolls and many blooms and unopened flower buds have been destroyed by one not fully grown worm. The bollworm is not only a voracious plant feeder, but it is also a cannibal. Older worms feed upon younger ones, and it has often been known to eat the chrysalids of the cotton caterpillar. With an abundance of vegetable food at hand, the larger worms will seize upon their small brothers, biting through the skin and feeding upon the juices of the body. In ears of corn the remains of several young worms are often found, while the strong, large worm which has destroyed them is the only living occupant of the ear. The larva occupies from two weeks to a month in reaching full growth.

Unlike the cotton caterpillar, the bollworm enters the ground in order to transform. It forms an oval cell composed of particles of earth held together by a loose, gummy silk, or the pupa may be perfectly naked. It is of a light mahogany color, darker toward the head, and the duration of this state is from one to four weeks.

The adult insect of the boll worm is a moth about the size of the cotton-worm moth, but has a stouter body and is more extensively marked, as well as more variable in its markings. Its general color varies from a dull ocher-yellow to a dull olive-green. The fore wings have a rather dark band near the tip and the hind wings are also bordered with a darker band. The wing veins are lined with black and the fore wings have also several dark spots. There is great variation in these markings, and they are intensified in some individuals and almost lacking in others. When the moth is at rest, the fore wings are slightly open, whereas in the cotton-worm moth they are closed in a roof-shaped manner. The moth flies normally about dusk, lays about 500 eggs, and is not a fruit feeder like the cotton-worm moth. During the day they hide in cowpeas and in clover, when these grow near the cotton field, and fly low with a quick darting motion when disturbed. About sunset they begin to feed upon the honey secreted by the cowpea and blossoms of clover, as well as upon the nectar of the cotton plant and other honey-secreting plants.

The average time occupied by the insect in its transformations from egg to the adult is about thirty-eight days. The number of annual generations is about five. They feed upon corn by preference until this becomes too hard to be readily eaten. The fifth generation makes its appearance about the middle of September, and about the middle of October, or even earlier, the caterpillars enter the ground for transformation to pupæ. The bulk of the bollworms hibernate in the pupa state underground.—(F. B. 47.)

How to Control the Bollworm.—The methods outlined for the boll weevil also include two of the most important measures against the bollworm, namely, fall plowing and securing an early crop of cotton. In this case fall plowing is very important, since it breaks up the earthen cells of the pupæ, which are the tender age of the insect, and exposes these forms to the winter weather which they are not used to. They can not stand this change in conditions, whether the winter storms are snows or merely cold rains. Wherever the weevil is not bad, fall plowing for the bollworm can be postponed until late fall or early winter. The bollworms feed by preference on corn, and are the same as the corn-ear worm. Advantage is taken of this taste of the worm to trap and destroy them by means of early June corn. It has been observed that the moths will lay their eggs on the silk of green corn, if this is obtainable, when they are flying, in marked preference to cotton or other cultivated plants. The moths of the third generation, which fly in August, do not like the hard ears of the corn for laying their eggs, and so they seek the succulent bolls of cotton for this purpose. If therefore some green corn is standing near by in silk, the cotton will be saved. When the cotton seed is planted, leave vacant strips every 25 or 30 rows across the fields. In these sow June corn about June 1, followed in ten days by cowpeas in alternating rows. This will put the corn in silk and the cowpeas in bloom about August 1. The blossoms of the cowpeas will attract the moths which will seek the nectar for their own food. They will then lay the bulk of their eggs on the silk of the corn which they can find so handy right by the peas. About three weeks later the ends of the ears can be cut off to destroy the worms. The fodder and the grain will entirely pay for planting the corn, and the cowpeas will enrich the soil which will produce more cotton the next year, and thus they will pay for themselves in a year's time. All the steps above advised for securing an early crop of cotton to escape the boll weevil should also be taken wherever the bollworm is the worse pest. The first two generations of worms do very little harm, and those that hatch from the eggs laid by the third generation of moths in August attack first of all the young tender bolls. There is plenty of evidence to prove that they do not attack the bolls that are about three-fourths grown at this time; that is to say, the young worms that hatch in August do not eat into the large bolls. Naturally big bolls will be found later in the season damaged by the large or full-grown worms. Most of the bolls that are three-fourths grown by the time the third or destructive generation of worms are on hand will escape injury.

The writer would call attention to the importance of not omitting any of the above mentioned steps in the control of the boll weevil and the bollworm. If anything is left undone, the pests will be more or less troublesome in spite of the attempts that have been made to control the pests. Success in the control of both insects depends on the principle of finish in the work. Half-hearted, slovenly methods will not succeed. If a man half does his work, he can not expect over half a crop. There is a great deal of truth in the proverb, "Whatsoever a man soweth, that shall he also reap."

In case leaf-eating worms are especially severe feeding on the leaves in certain fields, even with proper farm management, it is possible to poison them by means of powdered arsenate of lead dusted on the plants late in July or early August wherever the small worms are appearing on the leaves. A Champion dust gun should be used, as this is much more thorough than using a sack. The application of the dust can be repeated in ten days or two weeks, if the attacks are very severe. Paris green would burn the leaves of the cotton and is not recommended.—(Ark. E. S. Cir. 4.)

The Mexican Cotton-Boll Weevil.—The most important of the insects which damage the cotton boll, next to the bollworm itself, is the cotton-boll weevil. This insect is a small, grayish weevil, measuring a little less than a quarter of an inch in length. It is found in the cotton fields throughout the season, puncturing and laying its eggs in the squares and bolls. The larvæ measure a little over three-eighths of an inch in length when full grown, live within the buds and bolls and feed upon their interior substance. The squares attacked usually drop, but most of the damaged bolls remain upon the plant and become stunted or dwarfed, except late in the season, when they either dry or rot.

The insect passes the winter in the weevil state. It can be found in the cotton plant until late in December, and, in fact, as long as any portion of the plant is green. It is found most abundantly in the early winter hidden between the involucre and the boll, and later it frequently makes its way down into the dry and open bolls. The dry boll is probably not a frequently successful hibernating place.

With the cutting of the plants, or with the rotting or drying of the bolls as a result of frost, the adult weevils leave the plant and seek shelter under rubbish at the surface of the ground, or among weeds and trash at the margin of the fields. Here they remain until the warm days of spring, when they fly to the first buds on such volunteer plants as may come up in the neighborhood. They feed on these and lay their eggs on the early squares, and one or perhaps two generations are developed in such situations, the number depending upon the character of the season and the date of cotton planting. By the time the planted cotton has grown high enough to produce squares the weevils have become more numerous, and those which have developed from the generation on volunteer cotton attack the planted cotton, and through their punctures, either for feeding or egg-laying, cause a wholesale shedding of the young squares. It seems to be an almost invariable rule that a square in which a weevil has laid an egg drops to the ground as a result of the work of the larva; in the square on the ground the larva reaches full growth, transforms to pupa, and issues eventually as a beetle, the time occupied in this round approximating four weeks. Later, as the bolls form, the weevils attack them also and lay their eggs in them, and the larvæ develop in the interior just as with the squares. The bolls, however, do not drop.

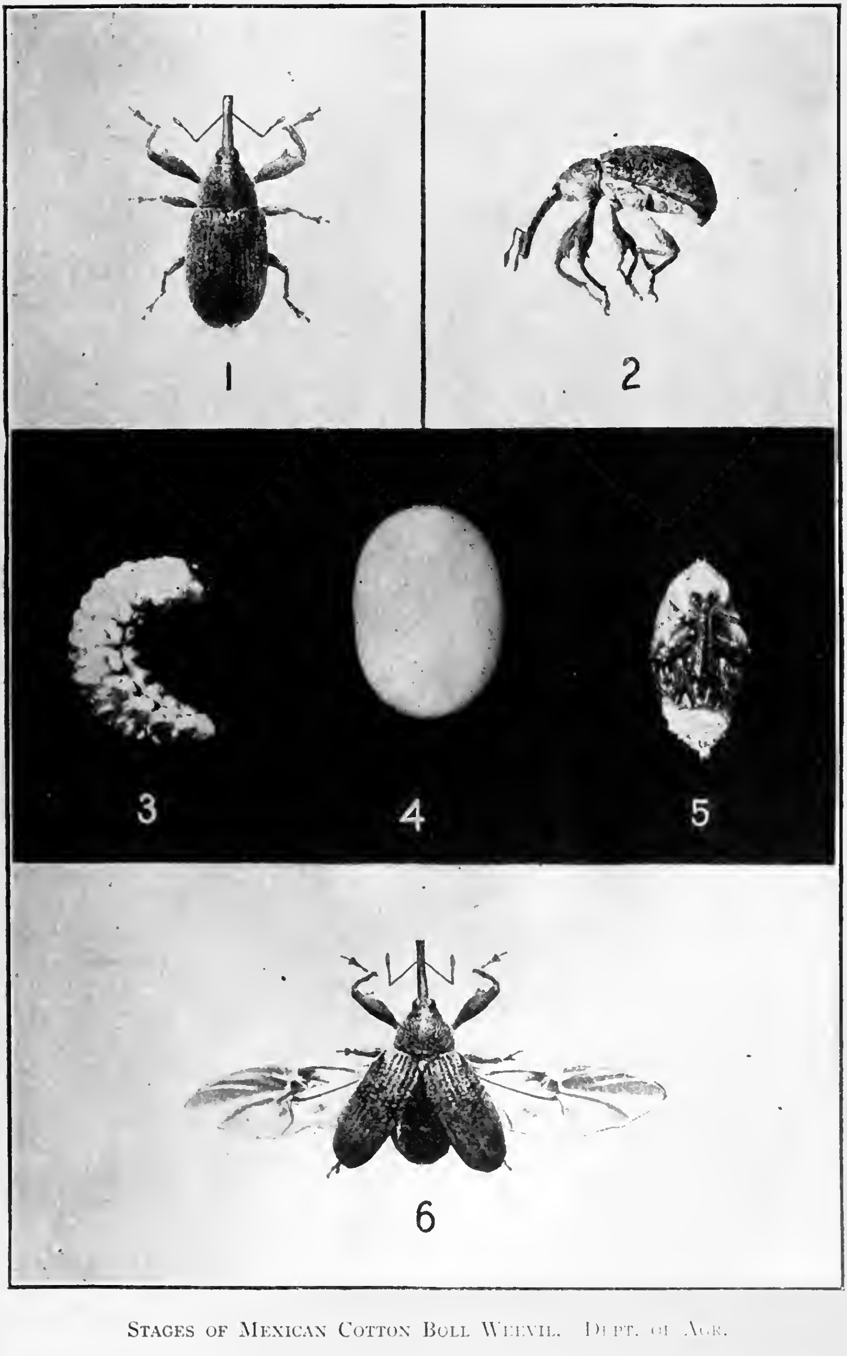
There is a constant succession of generations from early spring until frost, the weevils becoming constantly more numerous and the larvæ and pupæ as well. A single female will occupy herself with egg laying for a considerable number of days, so that there arises by July an inextricable confusion of generations, and the insect may be found in the field in all stages at the same time. The bolls, as we have just stated, do not drop as do the squares, but gradually become discolored, usually on one side only, and by the time the larvæ become full grown generally crack open at the tip. While in a square one usually finds but a single larva, in a full-grown boll as many as twelve have been found. In any case, however, the hatching of a single larva in a boll results in the destruction of the boll to such an extent that its fiber is useless. Where no serious frost occurs in December, the insects all, or nearly all, reach maturity and enter hibernating quarters. Whenever a heavy frost comes in this month, or before, the observations show that those insects which have not reached the beetle stage are nearly all killed.

There can be no question now that in the proper system of farming cotton a practically complete remedy for the weevil exists. In the first place, it has been established beyond question that the conditions of cultivation which make volunteer growth possible also makes the continuance of the weevil inevitable. Of first importance is the early removal of the old cotton in the fall, preferably in November or earlier. This can be done by throwing out the old plants with a plow, root and all, and afterwards raking them together and burning them. This treatment should be followed, as promptly as may be, by deep plowing, say to a depth of 6 or 8 inches. This leaves the field comparatively clean of old cotton stalks, facilitates thorough cultivation the following year, and, at the same time, collects and destroys all of the weevil larvæ and pupæ in the cotton at the time, and also most of the adults. The escaping beetles will be buried by deep plowing, and will not again reach the surface. Few, if any, of them will succeed in hibernating in the absence of cotton stalks and other ordinary rubbish in which they winter. Fields treated in this way have given a practical demonstration of the usefulness of the method.

The greatest danger from the weevil is due to the presence of volunteer cotton, which means early food for the weevils in the spring and abundant means for their overwintering, and the effort made to retain volunteer and get early cotton, or the "first bale," is a very serious menace to cotton culture within the weevil district.

This cultural method, if generally practiced, will undoubtedly prove a perfect remedy for upland cotton, and will vastly reduce weevil damage in the lowlands, where the weevil is more apt to winter, perhaps in adjoining woods or roadside vegetation. The early removal of cotton by the means suggested is especially advised whenever the presence of the weevil shows that the picking of a top crop is problematical. If this cultural method can be enforced, either by State legislation or by the co-operation and insistence on the part of landowners that their renters shall carry out the system outlined, the weevil difficulty can undoubtedly in very large measure be overcome.

In connection with the system of fall treatment of the cotton, constant and thorough cultivation of the growing crop is of considerable value, and is also what should be done to insure a good yield. With a crossbar to brush the plants many of the blossoms and squares containing weevils will be jarred to the ground and



Stages of Mexican Cotton Boll Weevil. Dept. of Agr.

buried, together with those already on the ground, in moist soil, and a large percentage of the material will rot before the contained insects have developed.

The following is an outline of the practical methods of controlling the boll weevil. These methods are based upon extensive studies and much field experimentation. They represent practically all that is known about combating the most important enemy of the cotton plant. They form a system consisting of several parts. The planter can insure success in proportion to the extent to which he combines the different essential parts.

Destroy the vast majority of weevils in the fall by uprooting and burning the plants. This is the all-important step. It results in the death of millions of weevils. It insures a crop for the following season.

Destroy also many weevils that have survived the preceding operation and are found in the cotton fields and along the hedgerows, fences, and buildings. This is done by clearing the places referred to thoroughly.

As far as possible, locate the fields in situations where damage will be avoided. This can not be done in all cases but can frequently be done to good advantage.

Prepare the land early and thoroughly in order to obtain an early crop. This means fall plowing and winter working of the land.

Provide wide rows, and plenty of space between the rows and the plants in the drill, for the assistance of the natural enemies of the weevil, which do more against the pest than the farmer can do himself by any known means. Check-rowing, wherever practicable, is an excellent practice.

Insure an early crop by early planting of early-maturing varieties, and by fertilizing where necessary.

Continue the procuring of an early crop by early chopping to a stand and early and frequent cultivation. Do not lose the fruit the plants have set by cultivation too deep or too close to the rows.

Where the labor is sufficient, pick the first appearing weevils and the first infested squares. Do not destroy the squares but place them in screened cages. By this means the escape of the weevils will be prevented, while the parasites will be able to escape to continue their assistance on the side of the farmer.

Use a crossbar of iron or wood, or some similar device, to cause the infested squares to fall early to the ground, so that they will be exposed to the important effects of heat and parasites.

Do not poison for the leaf-worm unless its work begins at an abnormally early date in the summer.

Do not go to the expense of buying special preparations for destroying the weevil. Disappointment and loss is certain to follow.

In some cases, where, for instance, a farmer has a small area of cotton growing for seed selection, it is practicable to resort to special means of control that would be impossible in general field practice. For the benefit of the many farmers in the infested area who are beginning to improve their cotton by selection, the following suggestions are made: The plat or plats should be far from timber, hedgerows, seed storage houses, and other protection for hibernating weevils. On the appearance of the earliest weevils the plats should be carefully picked over by hand. This should be continued until well after the squares begin to fall. If the falling of the squares continues it will be found practicable to rake them by hand to the middles or entirely outside of the plats to a bare place, where the sun will soon destroy the larvæ within. Of course all other general suggestions that are applicable in the field should be added to these special ones.—(Farmers' Bul. 344.)

Cutworms.—The first insect which attacks the young cotton plant in the spring is liable to be a cutworm. Soon after the young plants come up, and often after they are fairly well grown, they are liable to be cut off at the surface of the ground by one of these caterpillars, all of which have the habit of hiding beneath the surface of the ground by day and coming out to work at night. The granulated cutworm is probably the most common of the species collectively designated by Glover as the cotton cutworm. A number of other species, however, are undoubtedly concerned in this damage.

Plant-Lice.—While the cotton plant is yet young and tender, the damage which plant-lice do by gathering upon the young shoots and tender leaves and curling and distorting them may be very considerable. This insect is identical with the species which occurs commonly through the South, and the North, too, for that matter, upon melons and cucumbers. There is no single alternate perennial food plant, as in the case of the hop aphis, upon which the insect may be destroyed during the earlier or later portion of the year. As the cotton plant grows larger and stronger the work of the cotton aphis becomes of no importance, partly through the hardier condition of the plant, but also through the fact that the many natural enemies of the lice increase to such numbers as nearly to annihilate them. There will seldom be, therefore, any necessity for the application of remedies; and, indeed, as nothing can be done except to spray with a dilute kerosene-soap emulsion or a resin wash, it is a question whether it will not pay the cotton grower much better to replant the damaged spots.

Leaf-Feeding Caterpillars.—There are many Lepidopterous larvæ which feed upon the leaves of the cotton plant; few of them, however, are confined to the cotton plant for food. One of the species most commonly noticed, is known from its work as the leaf roller—a title under which another species may also be included. Both species are general feeders and are found in various parts of the country, the former upon apple, rose, peach, cherry, birch, clover, honeysuckle, bean, strawberry, and other plants, and the latter upon clover and grass. The larvæ of the former, in addition to folding the leaves of cotton and feeding within the roll, sometimes bore into the young bolls, but this method of damage is rare.

Several of the larger Bombycids also feed in the larval state upon cotton. Among these we may mention the large royal horned caterpillar, sometimes known as the hickory horned devil, a very large green caterpillar with long recurved red horns; the large green, somewhat hairy larva of the Imperial moth and the large spiny larva of *Ecpantheria,* as well as the yellow-green stinging caterpillar of the Io moth and the woolly bear caterpillars.

Two bagworms are also occasionally found feeding upon cotton leaves, constructing their cases from fragments of the leaves sewed together with silk. These are the common bagworm of the North, and Abbot's bagworm, a Southern species. Late in the fall the common grass worm, or fall army worm ranges through the cotton fields, feeding upon volunteer grass, and occasionally ragging the leaves of the cotton plant. Two allied native species also occasionally feed upon cotton leaves.

In a limited section of the country, namely, in portions of Texas and the Indian Territory, the so-called garden webworm occasionally does some damage to the cotton crop, as it did in 1885. Feeding principally upon corn, its injury to cotton is incidental, yet it may, in the early part of the season particularly, do some little damage to this crop. Its preference for corn is noticed mainly when fields overrun with pigweed and careless weed are broken up for planting, and, in fact, these weeds seem to be its natural food. It will probably never do serious damage to cultivated crops, except where these weeds have been allowed to run wild for a season or so and are then plowed under and the land planted to some useful crop. The small green caterpillars feed upon the leaves, concealing themselves between them during the day and skeletonizing them at night. The remedy for any or all of these leaf-feeding caterpillars, whenever one of them occasionally becomes so abundant as to threaten damage will be to spray with paris green, or dust it on dry, as for the cotton caterpillar, or spray with arsenate of lead.

Among the other insects which injure the foliage of the cotton plant, grasshoppers are the most prominent. Several species have this habit, and the list of cotton insects contains the names of fourteen which are found upon the plant. Here also the damage to cotton seems incidental; they feed by preference upon grass. The species which ordinarily cause the greatest alarm among cotton planters are the large American locust and the lubber grasshopper. The paris green treatment will again be effective here, but when grasshoppers occur in considerable numbers, attracting them to a mash made of sweetened bran and arsenic will prevent leaf feeding to a great extent.

Many leaf hoppers and several leaf-feeding beetles have been found upon the cotton plant, but need not be particularly mentioned here. In many portions of Texas the leaves are frequently cut off by the so called leaf-cutting ant. One of the few practical remedies against this destructive insect, which damages fruit trees and other field crops as well as cotton, consists in tracing the ants to their nest (which is often an extremely difficult thing to do) and destroying them there by copious applications of kerosene or bisulphide of carbon. Another method, which has been practiced with some success by an intelligent Texan, is to spread a line of cyanide of potassium across the well-defined path by which the ants leave their nest; this kills very many, and deters the ants from taking the direction of the particular path thus obstructed.

Puncturing of the terminal portion of the stalk by plant bugs occasionally occurs, but is comparatively rare. There is but one borer in the stalks of cotton, and that is the long-horned beetle. It is occasionally mistaken for an enemy to the plant, but investigation has shown that it lays its eggs upon and its larvæ bore into only such stalks as have been damaged by some other cause, such as rust. It follows injury to the plant, therefore, rather than causes it.

As in the case of the stalk borer just mentioned, numerous species of insects are found in damaged bolls which are the result, rather than the cause, of the damage. Several little Nitidulid beetles are found in such injured bolls. The larva of a little weevil deserves especial mention for the reason that it so closely resembles the larva of the Mexican cotton-boll weevil. In fact, the larvæ of both species are found living in the same boll. The perfect weevil is also among the various insects which are mistaken by the planters for the Mexican cotton-boll weevil, but its very short and blunt beak should at once distinguish it from the latter species. Aside from the true boll-worm, several of the caterpillars found upon the plant will occasionally gnaw the bolls, but this gnawing is in general incidental to their work upon the leaves. One of these is a leaf roller which attacks the forms and squares, much like the young bollworm, afterwards feeding upon the leaves. A congeneric species also bores into the young bolls. The reddish larva of a little Tineid moth belonging to a group mostly composed of leaf miners, is often found in the young bolls, and is generally believed by planters to act independently of bollworm damage. This statement, however, has not yet been satisfactorily substantiated so far as it refers to the bolls. In the young squares, however, the active little reddish larva is very often found as unquestionably an original inhabitant, and it undoubtedly frequently causes quite an extensive shedding of the squares. This, however, occurs only in the spring, at a time when there is surplus of bloom and when many squares can be spared without great reduction of the crop. Later in the season the larva is found boring in the unopened flower heads of various weeds.

There is a class of damage to the bolls which is known to planters as sharpshooter work, which is mainly caused by the punctures of a leaf hopper. The insect is most abundant from the first of June on through the season. Prior to the first of June it seems to prefer the young growth and foliage of poplars and other trees which may grow in the immediate vicinity. Where sharpshooter work is prevalent in the cotton field, year after year, and the trees which harbor the insects can be found in the early part of the season, a single application of kerosene emulsion to the lower parts of such trees or scrub growth might be made to advantage in the month of May.

An insect which at one time did very considerable damage to cotton bolls, particularly those which were far advanced or had burst, is the red bug or cotton stainer. This insect was never prevalent except in Florida, Georgia, and neighboring portions of South Carolina and Alabama. It is probably a West Indian species. Of late years, and more especially since cotton culture in Florida has given place to extensive orange culture, it has largely transferred its attention to the orange fruit. Earlier generations of this insect damaged the bolls by puncturing them and sucking the sap, causing them to become diminutive or abortive. Later, however, they entered open bolls, puncturing the seed and damaging the fiber by their yellowish excrement. These stains were indelible and greatly depreciated the value of the cotton in the market. The indelibility and beautiful color of the stains at one time suggested the use of the insects in making dyes. Experiments showed that the entire substance of the insect could be converted into a rich orange-yellow dye, which could be readily fixed upon woolens or silks by the alum mordant liquor, and that an ochreous yellow lake could be made from them by precipitating the coloring matter with gelatinous alumina. There has been, however, no commercial adoption of the results of these experiments. The best remedy against this species is suggested by the fact that in winter it will collect in numbers on piles of cotton seed, which can then be used as traps and the insects destroyed by the application of hot water.

The Stalk Borer.—This insect, which is quite different from other common borers, being black, with white stripes in its early stages, has been noticed boring into the stems several inches above the ground and causing the plants to wilt. It commonly feeds in various weeds, most commonly in the so-called bloodweed.

The Snowy Tree Cricket.—Mention should be made of the eggs of this insect, which are deposited in the stalks of cotton and various common weeds in the fall, since they have been frequently thought to be eggs of the boll weevil. These eggs are laid in a long row, leaving a long scar, composed of numerous punctures on the surface. They are deposited in the fall after the cotton is about grown and do no harm, so far as we are aware. The young which hatch from them the following spring, as well as the adults, feed very largely upon plant-lice, and are therefore more beneficial than injurious.

The Cotton Square-Borer.—During late May and in June cotton squares are often bored into by a small green caterpillar which many planters consider a stage of the bollworm and others have called the sharpshooter. Injury from this cause is often quite serious for a short time on a small area, as we have seen 10 per cent of the stalks entirely denuded of squares in small fields where this insect is abundant. The caterpillars hollow out the squares in the same manner as does the bollworm, often destroying all of those on a plant knee high and even boring into the stalk. They are bright green, oval, decidedly flattened, covered with short hairs which give them a velvety appearance, and with the head retracted under the front of the body, being quite unlike any stage of the bollworm. They are the larvæ of a dainty little butterfly which is very common around cotton fields. The eggs are laid on the leaves and stems of cotton, cowpeas, goatweed and various weeds. The larvæ have also been commonly found on hops, beans, and cowpeas, and seem to prefer the latter to cotton.

Fortunately for the planter, the large majority of the caterpillars are usually parasitized by flies about the size of the house-fly and also by small, wasp-like hymenopterous insects. The parasitic flies lay their eggs upon the caterpillar, and the maggots hatching from them bore into the caterpillar and feed upon its tissues, ultimately killing it and emerging from it or the pupa as adult flies. Over 90 per cent of the June brood have been found thus killed. It is usually hardly worth while, therefore, to attempt to combat this insect, as it is not often seriously injurious in the same locality year after year. Should remedial treatment be necessary, thorough dusting with Paris green would probably answer the purpose, as the young caterpillars, as do bollworms, feed to some extent upon the foliage before entering the squares.

The Cotton Leaf-Bug.—This insect was the cause of considerable damage in northern Texas in August and September, 1904. It punctured the squares and young bolls, either causing them to drop, or making the bolls shrivel or decay where punctured. The punctures in the bolls are indicated by small round black spots resembling diseased places, which gradually become larger and sunken. This insect has been known as a common inhabitant of cotton fields for many years, but injury seems to have been rare. It may be readily recognized by the bright red spots just beyond the middle of the wing. The young are light green marked with red. Several annual generations of the insect occur, but its habits outside of the cotton field are unknown. No successful means of combating it has yet been devised.

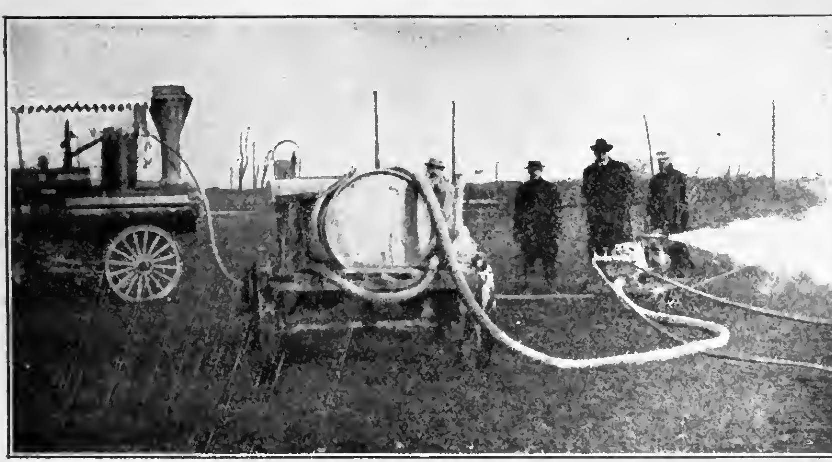
Other Plant-Bugs.—Similar injury to bolls, causing black spots and shrinking or decay, is caused by the large green plant bugs variously known as pumpkin bugs, stink bugs—from the very disagreeable odor emitted—and by other local names. The most common of these is bright green in color, and is undoubtedly a decidedly injurious insect, as it has been known to attack orange trees in Florida and strawberries and other garden crops elsewhere.

The leaf-footed plant-bugs injure the bolls in the same manner. These insects are also serious enemies of peaches and tomatoes in Texas. They breed commonly on thistles and should be destroyed wherever found.

Two other bugs somewhat resembling the so-called cotton stainer, though of a slaty or bluish color, margined with yellow or red, are frequently found in considerable numbers on the bolls and do some damage. The young nymphs feed upon low-growing weeds and have not been observed on cotton.

Click-Beetle.—A small species of click-beetle is frequently found on cotton blossoms and squares and working around holes made by the bollworm or square borer. It is of interest because frequently mistaken for the boll weevil where that insect is not well

Applying Paris Green to Tobacco with a Knapsack Pump Spray. Dept. of Agr.



Outfit for Disinfecting on a Large Scale. Dept. of Agr.

known. There is some evidence that these beetles sometimes eat into a square, but if so, the injury is rare and inconsequential.

The Cowpea-pod Weevil.—This is commonly an enemy of cowpeas, working in the pods and seeds of the developing peas, but has been observed eating into the stems of young cotton plants and sometimes attacking the young squares in Texas, Louisiana, and Georgia, the injury being more severe in the latter State, where cowpeas are more commonly raised. It is frequently mistaken for the boll weevil. —(F. B. 223.)

INSECT ENEMIES OF TOBACCO IN THE UNITED STATES.

For convenience of treatment, the insects are divided into two classes, (1) insects of primary importance; (2) insects of secondary importance.

Loss Caused By Tobacco Insects.—In 1907 the tobacco flea-beetle was exceptionally injurious in Kentucky and Tennessee and caused a loss of approximately $2,000,000. In Florida, in 1908, the tobacco splitworm caused a loss of $12,000 upon one plantation, an average of $150 per acre. The tobacco thrips injures wrapper tobacco seriously in Florida every year, frequently necessitating a regrading of from 10 per cent to 20 per cent of the crop and a consequent reduction in value of from 50 cents to $1.20 per pound. In years of severity the cost of fighting this pest may be as high as $20 per acre. The tobacco budworms have to be fought constantly in the shade-tobacco districts in Georgia and Florida. Although very little tobacco is ruined by these pests, it is estimated that the cost of fighting them ranges from $12 to $15 per acre, a tax of from $60,000 to $75,000 upon the growers for the 5,000 acres of shade tobacco. Tobacco hornworms are found in all tobacco fields and are the most serious pests of the industry. Their injuries vary from 2 per cent to 3 per cent in localities where they are scarce, and from 10 per cent to 15 per cent in localities where they are plentiful. The cigarette beetle, wihch infests cured and manufactured tobaccos, also levies a yearly toll of many thousands of dollars upon the tobacco industry. The total yearly loss to the tobacco industry from insect pests probably never falls below 5 per cent—a monetary loss of approximately $5,000,000, and it may be as high as 8 per cent to 10 per cent, entailing a loss of from $8,000,000 to $10,000,000.

The Tobacco Flea-Beetle.—The tobacco flea-beetle attacks plant beds and young plants in the field, and frequently injures tobacco until it is carried to the barn. The most serious outbreak on record occurred in the spring of 1907 in the dark-tobacco belt of Kentucky and Tennessee. Many plant beds were destroyed, and in many instances all plants upon resowed beds were destroyed. Frequently the flea-beetle seriously injures young tobacco in the field. The leaves are riddled with holes and new foliage was devoured as fast as it appeared.

Use only whole strong canvas in canvasing seed beds, with straight boards or logs for the sides; bank up the earth three or four inches against the sides, so that no holes are left beneath, and fasten the canvas closely and securely to the sides. Beds canvased in this way escaped injury in 1907.

Spray infested beds with arsenate of lead at the rate of 1 pound of arsenate of lead, paste form (one-half this amount of the powder), to from 12 to 16 gallons of water. Mix thoroughly and apply to the bed until every leaf is thoroughly dampened. Arsenate of lead adheres well to the foliage, and unless a very heavy rain falls the application need not be repeated until the plants have grown considerably. At setting time dip the tops of the plants in arsenate of lead made according to the above formula, and if flea-beetles continue to be injurious in the field spray the plants with the above insecticide, using a knapsack spray pump. With this pump one man can spray 5 to 6 acres of young tobacco in a day.

Cutworms.—Cutworms as a class are very injurious to tobacco. Their injury consists in cutting off the top of the young plant at or near the surface of the ground. Thirteen species have been known to be injurious to tobacco.

If possible, plow sod land in the fall, keep it free of vegetation for some weeks before tobacco is set, and thus starve the cutworms. If the field is infested with cutworms at setting time, use one of the following trap baits: Spray green clover with Paris green and drop handfuls of it about the field at intervals of a few feet; or, make a poisoned bran mash by mixing 1 pound of Paris green with 50 to 60 pounds of bran, sweeten with molasses, and drop about the field four or five days before setting time. If plants have been set, drop two or three small handfuls about each hill.

The Tobacco Hornworms.—These are the most serious pests of tobacco in the United States. They are found in all tobacco fields. The observations recorded here were made upon the southern species, but since the life histories and seasonal histories of the two species are so nearly alike, remedies that are recommended for the southern species will apply equally well to the northern. It requires forty-five to forty-eight days for the complete life cycle of the southern tobacco worm.

Eggs deposited June 1, June 15, July 1, or July 15 will hatch, the larvæ or worms will mature upon tobacco, will enter the ground, where they remain about three weeks in the pupal stage, and will emerge as moths of the second generation about July 15, August 1, August 15, and September 1, respectively. Larvæ that enter the ground after August 10 to pupate are very likely to hibernate. Therefore, only moths that are abroad before July 15 will produce a second generation.

The tobacco moth hibernates as a pupa in an oval cell, at an average depth of about 4 inches for second bottom soils of the Cumberland River. Numerous experiments at Clarksville, Tenn., 1907 to 1910, demonstrate that usually not more than 25 per cent of the hibernating stage pass the winter successfully. This stage is, therefore, a critical period in the seasonal history of the insect. Hence any artificial disturbance of natural conditions should produce an increased mortality. The most simple means of disturbance is by disking or plowing. Disking reaches only a small percentage of the cells and increases the mortality to a very slight extent, but plowing increases the mortality greatly. In plowing land it is necessary to plow only to the usual depth, for very few larvæ will enter the harder ground below to pupate.

Paris green, dusted on tobacco by means of a dust gun is in common use in Kentucky and Tennessee with very good results. Burning of the plant often occurs from the use of Paris green. This is usually, though not always, due to a failure to make an even application. From 1 to 2 pounds per acre are applied, without a diluent or carrier. It was found that 1½ pounds per acre, if carefully applied when there is very little or no breeze, is an effective remedy against all except the largest worms. The nearly full-grown worms should be hand-picked or they will do considerable injury before they succumb to the poison, if, indeed, they do succumb.

An insecticide has been found in powdered arsenate of lead that will not burn the foliage. This poison is, however, more costly than Paris green, for from 4 to 5 pounds should be applied per acre, at a cost of 80 cents to $1. Arsenate of lead must be mixed with a carrier. The writer finds that sifted ashes is the most satisfactory. Finely sifted air-slaked lime was tried, but did not dust evenly. An even, thorough application is absolutely necessary for good results. Only the arsenates of lead that are especially prepared for use upon tobacco should be used, for brands not thus prepared have been found to be too slow in their insecticidal action.

The Budworms.—In the shade-tobacco districts of Georgia and Florida the budworms are more injurious than the hornworms and are more costly to combat. The eggs are deposited in the tips or buds of the plant, and a single larva may eat through several leaves, rendering them unfit for wrappers and thereby greatly reducing their value.

Shade-tobacco growers in Georgia and Florida have to poison twice a week for the budworms during the growing season. The usual insecticide is Paris green at the rate of 1 tablespoonful to a peck of sifted corn meal. This mixture is sifted into the bud. According to W. A. Hooker, the annual cost of treating the budworms for labor and supplies averages from $12 to $15 per acre.

The Tobacco Splitworm.—The cosmopolitan tobacco splitworm was first reported from tobacco in this country by Prof. Gerald McCarthy. In 1898 Prof. A. L. Quaintance stated that the larvæ usually made their appearance about the last of May at Lake City, Florida; that the life cycle was found to be not more than twenty days; that the larvæ are miners, living between the upper and lower epidermis of the leaves, and that by their work they render the leaves worthless for wrappers. They have the habit of leaving their mines and crawling over the surface of the leaf to mine in another place. This habit led Professor Quaintance to suggest an arsenical spray. According to him the winter may be passed either as larvæ or pupæ in rubbish upon the surface of the ground. It therefore becomes advisable to destroy all trash in and around tobacco fields and tobacco barns. Pick infested leaves every fourth day.

The Tobacco Thrips.—It was first reported injurious to tobacco in Florida in 1902. It sucks the leaves along the veins, producing a whitened inelastic vein which breaks too easily for use as a wrapper. Mr. Hooker states that the life cycle requires only twelve to thirteen days in May and June and that the insect probably hibernates as an adult. Preliminary experiments have led the writer to suspect that the adult has a subterranean habit of hibernation. It feeds upon many species of plants. He found that kerosene emulsion was the cheapest and most efficient remedy. He recommends the following stock solution: Kerosene, 2 gallons; hard soap, ½ pound; water, 1 gallon. A strength of 1 part stock solution to 10 parts of water proved to be effective in killing the thrips, but it was found to injure tobacco seriously if applied in strong sunlight. Spraying is done, therefore, late in the afternoon and at night, beginning not earlier than 5 o'clock on bright days.

The Tobacco Crambus.—The tobacco crambus was recorded from tobacco by the late Prof. W. G. Johnson in 1899. Johnson stated that it was very injurious to Maryland, boring and feeding upon the stems of the newly set plants.

The Cigarette Beetle.—Severe loss to the tobacco trade is caused every year by the cigarette beetle. It breeds in practically all cured tobaccos, except those richest in nicotine. Small lots of infested tobacco, like cigars, cigarettes, and boxes of pipe tobacco, may be successfully treated by opening the boxes so that the gas will enter, placing them in an air-tight box, and fumigating with carbon bisulphid, using 1 ounce of the liquid to every 50 or 60 cubic feet of space. The liquid should be placed in a shallow receptacle above the tobacco, for the gas is heavier than air. Large buildings or rooms may be fumigated with this gas. In these cases securely chink all cracks, place the liquid in pans near the ceiling, and fumigate for from 12 to 24 hours, using 1 pound of carbon bisulphid to 600 or 800 cubic feet.

Do not bring fire into the room while the liquid is evaporating, for the gas is very inflammable. Air the room before entering. A small amount of the gas may be inhaled without ill effects, but a slight dizziness or nausea is the signal for retreat. Hydrocyanic-acid gas has been used to fumigate factories with good results. Great caution being exercised in using it, as it is highly poisonous. No satisfactory method of treatment has been found for this beetle in baled tobaccos. This question is a serious one with cigar manufacturers and demands investigation.

The most serious insect of secondary importance that attacks the seed bed is the grouse locust, which, as reported by Mr. Metcalf, was found seriously injuring plant beds at Stem, N. C. This species has also been found rather common upon seed beds at Clarksville, Tenn. Mr. Metcalf advises that plant beds should not be placed near low, marshy ground. As a remedy he advises the spraying of a strip 3 feet wide around the plant bed with kerosene emulsion. The kerosene-emulsion repellent and the arsenate of lead spray will be found efficient remedies for insects attacking the plant bed.

The most serious injury to transplanted tobacco, besides that by the insects of primary importance, is perhaps by wireworms. In June, 1909, investigators found larvæ of the tomato stalk borer boring in the stem and midribs of young tobacco at Clarksville, Tenn. Z. P. Metcalf records that the mole cricket was injurious locally in North Carolina by cutting off the young plants. W. A. Hooker records two tenebrionid beetles and the snout-beetle as hiding beneath and eating the wilted leaves of newly set tobacco plants in a field at Quincy, Fla.

The worst depredators of this class (insects affecting the foliage) belong to the Orthoptera and to the Hemiptera. Of the Orthoptera the most injurious species is perhaps the migratory locust, which occasioned serious injury to tobacco fields in the vicinity of Clarksville, Tenn., during 1910. This pest injures tobacco by eating holes in the leaves and by ragging the edges. It was found that poisoning tobacco for the hornworms was an efficient remedy against this insect. Other species taken on tobacco are six grasshoppers, two tree-crickets, and two long-horned grasshoppers.

Hemiptera injure tobacco by sucking the stems and midribs, thereby causing wilt, and by sucking the leaves, in which case discolored and deadened areas result. Probably the most injurious species is the tobacco suckfly. Professor Quaintance states that this insect is very widely distributed in Florida, and it has been recorded from Louisiana, Texas, Mississippi, and Alabama. It causes wilt of tobacco, and plants severely attacked are believed never to recover. According to Professor Quaintance it is injurious only upon late tobacco. He found that a tobacco decoction made by boiling 1 pound of refuse tobacco leaves for one hour in water, diluted in 1 gallon of water and sprayed upon the plants, was an effective remedy. A 10 per cent strength of kerosene emulsion was also found effective but very injurious to foliage.

Besides the flea-beetles, which attack tobacco in the field as well as in the plant bed, the gray blister beetle is perhaps the worst pest among the beetles. Mr. Z. P. Metcalf states that it severely ragged tobacco in some fields in North Carolina in 1909. The twelve-spotted cucumber beetle has been observed feeding upon tobacco at Clarksville, Tenn., and the Colorado potato beetle has been reported from tobacco. Future observations will undoubtedly disclose that many other beetles also feed to some extent upon tobacco.

The two snout-beetles have been recorded by Dr. F. H. Chittenden as breeding in tobacco stems. The former has been reported from Texas to Florida, while the latter has been reported only from Florida. Injury has rarely been severe. Doctor Chittenden recommends clearing the tobacco fields of all stalks and of all rubbish in which the beetles could find shelter, dipping young plants in arsenate of lead at setting time, and later spraying with the same insecticide to kill the beetles while they are feeding. Wire-worms are the principal insects of secondary importance that injure the root and stems of tobacco. Besides the cigarette beetle, only three species are recorded as injuring cured and manufactured tobaccos. These are the rice weevil, the drug-store beetle and a dermestid beetle. The remedies are the same as for the cigarette beetle.—(Year Book Sep. 537 D. of Ag.)

PESTS OF HOUSE-PLANTS.

There are but few kinds of house-plants which are not, sooner or later, attacked by insect enemies. Among the most common of these enemies are plant-lice, the so-called red spider, thrips, scale-insects and mealy-bugs. Most housewives are familiar with the small, soft-bodied green or blackish plant-lice which often multiply in great numbers on certain kinds of house-plants. These lice live on the juices of the plants which they suck out by means of their beak-like mouth parts, which they force into the tissues in a similar way that a mosquito bites us.

The so-called red spider is a minute, spider-like mite, which often swarms over the undersides of the leaves, forming thereon a network of silken threads. Thrips are very small, slender and active little creatures which live mostly on the under sides of the leaves, causing yellowish spots where they have fed.

Several kinds of scale-insects infest house-plants. Some of them are dark brown and the shape of a half-pea when fully grown. The young of these brown scales are lighter colored and flat, closely adhering to the plant from which they suck their food, like the plant-lice. Palms and some other plants are often infested with a smaller, round flat scale about the size of a pin-head. Coleus plants and a few others are often badly infested with small, whitish insects, known as mealy-bugs from their peculiar mealy or cottony appearance. They are closely related to the plant-lice and scale-insects, and suck their food from the plants in a similar manner.

When good water pressure is available, the simplest and usually an effective method of controlling most insects infesting house-plants is to thoroughly spray the plants with water through a hose and nozzle at frequent intervals. Take the plants outdoors, and by the application of such a spray one can usually knock off most of the insects, excepting the scales. Plant-lice, red spiders, mealy-bugs and thrips will usually succumb to such treatment. When a forceful water spray is not available, a small spray-pump may be substituted and a solution of whale-oil soap (one pound in five or six gallons of water), kerosene emulsion or a strong tobacco decoction may be used as a spray on the plants. It is necessary to aim this spray so as to hit the insects. For scale-insects the housewife must resort to hand work. Take strong soap-suds, or better, the whale-oil soap mentioned above, and with a sponge or rag, sometimes assisted by an old tooth-brush, thoroughly wash the infested plants, thus removing the insects. It is necessary to repeat this operation in a week or two to get those that were missed before with their progeny. One should always thoroughly rinse off the plants with water after these soap applications.—(New Series I No. 2 Cornell Reading Course for Farmers' Wives.)

The Greenhouse Orthezia.—This insect is a tropical insect somewhat closely allied to the common mealy bugs familiar to every florist. It has its mouth parts formed for piercing and sucking, and obtains its nourishment by imbibing the plant sap, like all other species of the family to which it belongs. The young are very small, and would hardly be discerned on a plant were it not for the presence of snow white plates of waxy matter which occur on the back and sides, and which contrast strongly with the darker background of the body. The adult females are about the size of the head of a pin and resemble the young in appearance, but bear in addition to the white plates on the back and sides a somewhat cylindrical sac of the same substance, which projects for some distance behind the insect and in which the eggs are carried. At the posterior end of this sac is an opening through which the young crawl soon after hatching from the egg. The young are then quite lively, and scatter well over the stem and underside of the leaves of the plant. As they grow older they become sluggish, but always retain their power of locomotion. The mature males have a single pair of wings, and, being very minute and also rare, are seldom noticed.

The Greenhouse Orthezia has not as wide a range of food plants as the Mealy Bug, but it attacks a greater variety of plants than most florists are aware of. It has been found on lantana, verbena, lemon verbena, coleus, salvia, libonia, peristrophe, ipomœa, ageratum, cineraria, eupatorium, stevia, chrysanthemum, pilea, segar plant, oxalis, pelargonium, abutilon, malvaviscus, fuchsia, heliotrope, periwinkle, potato, mint, white violet, and forget-me-not. In tropical countries it is reported as infesting citrus plants. On all in the list as far as chrysanthemum, when allowed to increase without molestation in the insectary greenhouse, it became sufficiently injurious to cause the death of the plant.

Coleus appears to be the most favorable plant for its increase, and it is of its injuries to this plant, especially to the variety known as *verschaffeltii*, that florists most frequently complain. During the winter it is very destructive to the coleus cuttings in the greenhouses, and, if at all numerous on the young plants when they are set out in spring, it is almost sure to increase in a short time to such prodigious numbers that it kills or greatly weakens the plants before frost in the fall.—(Bul. 28 Mass. E. S.)

As the plants which this pest infests are mostly tender annuals, it is difficult to destroy the insects with insecticides without injuring the plants. This makes preventive measures of more importance to hold the insects in check than remedial ones. Most of the plants are used for bedding purposes, and as these are nearly all placed out of doors in the summer, not many insects would get into the houses to breed and cause trouble in the winter if the plants brought in from outside and the few which may have been kept in the houses during the summer were thoroughly cleaned in the fall. Cuttings for stock should only be made from uninfested plants, and cuttings or plants received from other dealers should be examined at once and rejected or at least thoroughly cleaned if found infested; this last point is an important one, as the insect has undoubtedly been introduced into new districts through the agency of auction houses, and has often become extremely abundant before being recognized as a new enemy.

These precautionary measures should be supplemented by frequent syringing with as severe a spray of water as the plants will stand if any insects make their appearance. Many plants like coleus, however, will not stand a syringing severe enough to wash off all the insects, and so resort to an insecticide is often found necessary.

Of the florists who use an insecticide against this insect, nearly all use fir-tree oil, and all who do speak very highly of its effectiveness. This substance has been tried at the Insectary, and when used in the proportions recommended by its manufacturers for the Mealy Bug, it has been found to be very efficient in destroying the Greenhouse Orthezia. Its costliness is the greatest objection to its use.

Kerosene emulsion is another good insecticide, and one that is not as commonly used by florists as it deserves to be. Doubtless this is because it is a little troublesome to prepare, but those who are willing to take this trouble are well repaid. The emulsion which was found to be the most efficient on the Greenhouse Orthezia in experiments conducted at the Insectary was Cook's emulsion. This is made by adding one pint of kerosene to a boiling solution of one-quarter pound of hard soap in two quarts of water, and churning the mixture thus formed until it is thoroughly emulsified, which takes about five minutes; for use, the emulsion is diluted with twice its bulk of water. It must not be expected that every insect will be destroyed by one application of either fir-tree oil or kerosene emulsion, and besides, the eggs in the ovi-sac are not always reached. Dipping the plants in the substance and holding them submerged for a few seconds appears to be a more successful method than spraying them. The insects remaining on the plants left out of doors are killed by the first severe frost, so no danger need be apprehended from them.—(Bul. 28, Mass. E. S.)

Thread Scale.—This is a long narrow black scale attacking palms, pandanus and many other plants in greenhouses. It has been taken in Connecticut only at one greenhouse in New Haven, where it was quite abundant. Little is known of its life history, and the male is unknown. The female shell is from 2 to 3 mm. long, and about eight times as long as broad, and more or less curved. The writer has had no experience in combating this scale, but the same treatment used for other greenhouse scales will doubtless hold it in check.

Chaff Scale.—This is common on various greenhouse plants, especially orange and lemon. It is oval in shape, with the molted skin at one end, and is light yellow in color. It is usually found in clusters. The common sprays used for greenhouse scales seem to be effective against this species.

Soft Scale.—It is an oval, slightly convex brown species commonly found on citrus trees, oleanders and many other plants in greenhouses. Females are viviparous, but the generations are not well marked. Soap and water or kerosene emulsion will readily destroy these scales at any season of the year.

White Scale; Oleander Scale.—This scale is a pest of greenhouses, where it attacks oleander, croton, ivy, palms, camellia and many other plants. It is nearly circular in shape, and white or light grey in color, making it conspicuous on the green leaves and stems. It probably breeds continuously in greenhouses. Fumigating the house with hydrocyanic acid gas, spraying the infested plants with either whale oil or common soap (1 lb. in 8 gallons of water) are the remedies for this scale.

Circular Scale: Fig Scale.—Rubber plant, orange, palms, camellias and oleander in greenhouses are often infested by a round dark-colored scale which stands out prominently from the surface of the leaves. In fact it is almost conical in shape, reddish brown or nearly black, with an orange apex. Presumably it continues to breed throughout the year under glass, and continued spraying is necessary to keep it in check.

Red Orange Scale.—A light grey or brown circular scale about 2 mm. in diameter occurring on oranges and lemons in the markets and sometimes infesting citrus trees and palms in greenhouses. The scale is somewhat translucent, showing the reddish insect beneath. The female is reniform in shape. This scale causes much injury in the orange groves of California, and also occurs in Florida.—(Fifth Report of the Entomologist, Conn. Agr. Exp. Sta.)

Morgan's Scale.—It is of about the same color as the preceding species, but is flatter, and projects only slightly from the leaf. Mr. H. E. Hodgkiss studied this scale at the Massachusetts Agricultural College, and found that several generations are produced each year, but these overlap so as to become indistinct. The females bring forth living young, are parthenogenetic, and males are unknown. Fumigating the house with hydrocyanic acid gas, using 7.5 grams potassium cyanide for each 100 cubic feet of space, for forty minutes, after dark, with the plants free from moisture, is the treatment advised by Mr. Hodgkiss after making many experiments. It is probably a safe remedy for nearly all of the greenhouse scales.—(Fifth Rep. Ent. Conn. E. S.)

*Mealy Bugs.**—These are probably the most universally distributed and well known of all greenhouse pests. No florist, and but few housewives, attempting to maintain a window garden, but are familiar with them, to a greater or less degree. Two species occur in Maryland.

The Short-spined Mealy Bug.—This bug, in the adult form, is about 4 mm. in length and 2 mm. in width oval or elliptical in outline, with a fringe of short spines encircling the body. These spines are thirty-four in number, and of about equal length, those on the anal end of the body being slightly longer than the others. The body is covered with a white waxy mass, giving the insect its common name of *mealy bug.* If this wax is removed the body is seen to be of a brownish color.

* See illustration on page 195.

The female lays from 300 to 500 eggs, depositing them in a mass beneath the tip of the abdomen, and covering them with cottony wax filaments. As the mass of eggs increases in size, owing to the deposition of more eggs, twenty to thirty being deposited every twenty-four hours, the body of the female is gradually tipped upward, until it finally assumes a position almost perpendicular to the surface of the leaf or twig. Egg depositing continues for from a week to ten days, and when it is finished nothing is left of the insect except a shrunken and dried-up skin. The eggs hatch in about two weeks from time of deposition, those first laid hatching first, so that there is a difference of several days in the ages of the larvæ from the same batch of eggs. The larvæ resemble the adults in appearance, except that, when first hatched, they are quite small, and not covered with the white, waxy filaments. They remain in the mass of waxy secretion with which the egg mass was covered for several days before crawling out upon the plant to begin feeding. Owing to the difference in time of hatching of the eggs, considerable difference is noticed in the size of the larvæ from the same batch of eggs, and it is usually possible to find insects of all sizes and ages upon the plant at any time. Their development is rather slow, it requiring about six weeks to two months for them to reach the adult. Most of this time is spent on the underside of the leaves, sucking the juices from the plant by means of a slender sucking tube, which is inserted into the tissue along the midrib and veins.

A few weeks after the eggs have hatched small masses of the filamentous matter will be noticed on the under side of the leaves, usually a short distance from the veins of the leaf. These are the pupæ of the males. The males are small, winged insects, very slow and awkward in their flight, and not readily observed, because of their color, which is a kind of olive brown. They appear and mate with the females when the latter are about half grown. Of greenhouse plants, the coleus geranium and sago palm seem to be its favorite food plants, but it is often found on many others.

The Long-spined Mealy Bug.—This species of mealy bug, as has been said, while quite common in Maryland greenhouses, does not seem to be as abundant as P. citri. It is readily distinguished from that species by the length of the spines at the anal extremity of the body, the last two of which are as long as, and sometimes longer, than the body. In its life history and habits it is so nearly identical with the foregoing species as to render unnecessary any separate treatment, while its food plants are fully as numerous, and many of them the same.—(Bul. 119, Md. Agr. Exp. Sta.)

The Black Scale.—This is another very widely distributed scale, being found in nearly all parts of the world. In the warmer climates it infests outdoor plants, but in our latitude, and throughout most of the United States, it occurs only as a greenhouse pest. It is not particularly destructive, but often occurs in great numbers, and always accompanied by a black fungus, which lives upon the honey dew excreted by the insects, thus rendering the attacked plant very unsightly in appearance.

The scale is quite large, slightly longer than wide, and quite convex, with a prominent ridge or carina down the middle of the dorsum, and two transverse ridges, the three ridges forming a rough imitation of the letter H. The sides of the scale are quite flaring, and more or less corrugated. Altogether, the dorsum presents a very rough appearance. In color this scale is very dark brown to almost black.

The females of this species seem to be more than ordinarily prolific, even for scale insects. Dr. Coquillet reports having counted as high as 2,200 eggs and young larvæ from a single female. It is probable, however, the average number will be somewhat less than this, as out of a dozen specimens examined by the writer, in no case were over 1,200 eggs found, and usually less than that. The first eggs begin hatching, however, sometime before ovipositing is finished, and therefore it is possible for a considerable error to be made in estimating the number of eggs actually produced. The young, after hatching, remain for a short time beneath the mother scale, and then crawl out and begin feeding. Unlike most other coccids, this species never, or at least not until quite late in life, loses the power of locomotion, but is able to change its location at will. They feed either upon the leaves or stems; palm leaves have been observed almost completely covered with them, and the dirty black fungus which accompanies them. Happily, the life cycle of this insect is a long one, one generation requiring almost a year to complete its cycle. The egg-laying period for a single female stretches over several months, and the hatching of her eggs covers a like period, so that one will find crawling larvæ upon the plants at almost any time. For this reason it is extremely difficult to obtain accurate data in regard to the exact length of any period of the insect's life.

The black scale is by no means as general a feeder in the greenhouse as some of those previously mentioned. It confines its attacks principally to the citrus trees and palms, but may, at times, be found infesting rose, oleander, Ficus, Euonymus, Cycas revoluta, and possibly others.—(Bul. 119, Md. E. S.)

The Black Aphis of Chrysanthemum.—The black aphis, or "black fly," as it is erroneously called by most florists, is too well known to warrant a detailed description here. Wherever chrysanthemums are grown it will be found sucking the sap from the stems and leaves. The insects gather about the terminal buds upon the young growth, and, if neglected, soon become so numerous that the growth of the plant is completely stopped. The rate of increase is almost incredible, and has led some growers to believe that the pest is a product of spontaneous generation. Some observations taken by the writer will serve to illustrate the remarkably rapid rate of increase in this species. Young agamic (that is, non-sexual) females isolated upon separate plants, began producing young in every case within eight days after birth. Each female produced from four to sixteen young lice per day, and the average number produced by each was about two hundred. These young lice all insert their beaks, and begin drawing sap almost immediately after birth, and without wandering far from the mother aphis, unless crowded for room, when they move away to a place where they will not be interfered with, which may be lower down the stem, on the under side of the leaf, or upon a new plant. It can readily be seen from the figures above that the number of lice upon a plant, which has been neglected for two or three weeks, will be something enormous, even with but one female on the plant to start with. Winged females are produced at intervals, and these fly to other plants and bring forth young in the same manner as the wingless form, that is, without the intervention of the egg state. It is not known how long this reproduction of the species agamically can continue under greenhouse conditions, but it is certain that a sexual form of female is produced at intervals which, after mating with the males, produces eggs from which agamic females again appear, and give birth to living young.

So far as known to the writer, this species attacks no other plant than the chrysanthemum. Other species of black aphids occur in conservatories, notably upon the rose and violet, which are often mistaken for this one, but which are distinct species.—(Bul. 119, Md. E. S.)

The Green Aphis of the Rose.—The green aphis of the rose is one of the greatest drawbacks to successful rose culture in greenhouses. It is found attacking the leaves and young twigs wherever the rose is grown, and occasions the florists considerable expense and labor in its control. The species was originally described from Europe. Some doubt exists as to whether the European species and our own are identical, but most writers who have treated the subject have considered them as the same.

The winged form is rarely seen, practically all reproduction being carried on by the viviparous form. Breeding in this form is extremely rapid, one female producing from four to ten young per day, and it requiring but eight days to two weeks for these young to reach maturity. It is surprising how soon plants will become reinfested after a fumigation that apparently killed all but a few scattering individuals. Three or four weeks suffice to reinfest them almost or quite as bad as before the fumigation. The favorite part of the plant for these aphids to feed upon seems to be the extreme ends of the new growth or the flower buds. They not infrequently become so thick about the buds as almost to cover them, and when this occurs the bud is rendered worthless. In most of the essential points of its life history this species closely resembles the chrysanthemum aphis. —(Bul. 119, Md. E. S.)

The Melon Aphis.—This plant louse is a well-known enemy of outdoor grown plants, especially those belonging to the Cucurbitaceae, and has been mentioned frequently as a pest of greenhouses as well. It is a general feeder, affecting many weeds and garden vegetables, besides the Cucurbits. In greenhouses the writer has found it only upon cucumbers, begonias and an Hibiscus, but it doubtless affects many others also. Like other similar species it is known to florists and gardeners as "green fly," no attempt being made to differentiate between it and other greenish-colored species of

Aphididae. The color of the species varies greatly, ranging from almost yellow to nearly black, but the prevailing color noticed by the writer is a more or less purplish green. Like the other aphid pests of greenhouses, this species increases very rapidly, and if neglected soon injures its host. The lice confine themselves principally to the under side of the leaves of the cucumber, but those found upon the begonias and Hibiscus were attacking the flower buds and terminal shoots of the plant, and entirely ignoring the leaves. The life history is practically the same as that of the chrysanthemum aphis, both winged and wingless agamic females being produced, and a generation of sexual individuals developing at intervals. The females possessing wings are much more numerous in this species than for any of the others found in greenhouses.

The Brown Aphis of the Violet.—The species is sufficiently distinguished from the green aphis affecting the violet by its color, which is dark brown, both in the winged and wingless forms. The winged form is still more easily recognized, because of the dark-clouded venation of the wings. The insects are generally found on the stems of the leaves well down towards the crown, where they are not readily seen, and where they are difficult to reach with any kind of spray. Their injury is rather a stunting of the plant, causing it to produce weakly and imperfect flowers, than the actual killing of it.

The Brown Aphis of the Violet.—In this species, as with other aphids, breeding is so rapid as to seem almost incredible. In no point of its development does it differ materially from the foregoing species. Winged agamic females, which produce agamic young, and enable the species to spread, are developed at intervals, but seemingly without any regularity, appearing to depend more upon circumstances as regards food than upon anything else. When a plant becomes so completely infested as to cause crowding among the insects, the winged females appear, and in this way enable the species to survive. As the wingless individuals are unable to spread to new food plants, to any extent, but must remain upon the plant where born, some such provision as the winged female is necessary. Otherwise the insects would become so numerous upon the original plant as to kill it, and thus the species would exterminate itself. A sexual generation no doubt occurs also, but has not been observed. The species occurs on no other plant than the violet, so far as known.

The Red Spider.—Notwithstanding its popular name, this pest is in reality not a spider at all, but a tiny mite. For the purposes of this paper it will not be necessary to go into a detailed and technical description, since apparently only the one species is likely to be found on greenhouse plants. In some respects the name red spider is a misnomer, as the mites vary in color from pale pinkish to almost black, depending upon the age and food plants of the individuals. Some specimens are even greenish, with two or more darker spots on the back of the abdomen. They are extremely small, though visible without the aid of a glass, but are likely to be overlooked until attention is called to them by the injury to the plants. Attention is sometimes drawn to them by reason of the thin white web which is spun on the surface of the leaves, but it is usually only in cases of bad infestation that the web becomes apparent. The injury to the leaves is quite characteristic. The leaves of an infested plant first become dotted with brownish patches, usually on the under side, and then gradually wither and dry up.

The eggs of the mite are deposited on the underside of the leaves, from five to ten being laid each day, and one female will lay from 80 to 100 eggs. These hatch in three or four days, under favorable conditions. Observations indicate that in a greenhouse three to four weeks are sufficient for the completion of a life cycle. It will thus be seen that the rate of increase will be something enormous, if the mites are left undisturbed. Fortunately, the ordinary methods of caring for plants under glass destroy large numbers of them, and thus partially hold them in check.

The list of food plants of the red spider is a long one, including many of the common greenhouse plants. The carnation, rose, geranium and violet are especially liable to attack, however, and it not infrequently causes great damage to these plants. Probably the rose and carnation growers are the greatest sufferers, it sometimes occurring that even well-cared-for houses become so badly infested as to render the crops of these flowers almost valueless, owing to the stunted condition of buds which have been robbed of their natural nourishment.—(Bul. 119, Md. Exp. Sta.)

Thrips.—Carnations are not infrequently badly damaged by tiny insects called thrips, which are closely related to the true bugs, or Hemiptera. The thrips work in the flower buds, causing small, irregular white blotches to appear on the petals, and thus rendering them imperfect. In case of bad infestation, the flowers are rendered unsalable, and the florist sustains a heavy loss. The blotches are caused by the sucking of the sap from the petals before the flower is open, causing the tissue to turn white.

The insects are less than a tenth of an inch long, very slender, and in the adult form dark colored, almost black, with four small membranous wings carried flat on the back. The head is quite small, and the abdomen long and slender, giving the insect the appearance of being pointed at both ends. The larvæ are slightly lighter in color than the adults, and have no wings, but otherwise they look much alike. When disturbed the thrips will frequently elevate the tip of the abdomen, as if intending to sting. They are very active, leaping or flying readily, or wriggling out of sight so quickly among the bases of the petals when the flower is torn open that it is very difficult to capture one of them. The life history of the greenhouse species has never been satisfactorily worked out, but it is probable that the eggs are laid in the tissue of the plant in the leaf or stem, as with other species of the genus, and when the eggs hatch the young larvæ crawl out and feed by sucking the sap, as do the adults. The carnation is the only greenhouse plant liable to be severely injured.—(Bul. 119, Md. Exp. Sta.)

The White-Fly of Greenhouses.—The white-flies as a family are tropical insects. In warm climates many species are abundant out of doors, but in cold regions only a few sorts appear to be able to survive from season to season, except in the shelter of the heated greenhouse.

The egg of the white-fly common in our greenhouses is a minute oblong object slightly pointed at one end. The rounded end is attached to the under surface of the leaf so that the egg hangs perpendicularly downward when the leaf is horizontal. Its length is less than 1-4 mm. or about 1-100 inch. When first laid the eggs are slightly greenish yellow, but they soon become darker. Just before hatching the color is a dull glossy brown. In a little less than two weeks (13 days according to our observations) the eggs hatch into little nymphs, which move about over the surface of the leaf for a few hours, perhaps a day; then they insert their tiny beaks into the succulent tissues of the leaf and settle down, taking on the appearance of a minute scale.

The little scale remains in position two weeks or longer; then it is a tiny flattened object, with oval outline, of a slightly greenish-yellow color, in size about 1 mm. by ½ mm. Under a hand lens one can see that it is scantily clothed with minute bristles, having a denser fringe along the margins of the body. Finally a T-shaped rupture appears in the back skin of the insect, and the adult white-fly emerges to continue the propagation of the race.

The mouth parts of both the nymphs and adults of the white-fly are formed for sucking, and the insects are injurious in both these stages. They insert their tiny beaks into the succulent tissues of the under surface of the leaf; the latter soon shrivels, dies, and later falls to the ground. As the adults prefer to oviposit upon the younger shoots the lower leaves of infested plants die first.

Observations and experiments carried on very recently have shown that by far the most harm was caused by the work of the nymphs. Adults kept in breeding cages with plants lived a longer time than those without food, yet in no case did the plants die where adults alone were present.

Some time after the leaves are infested the under surface is covered with a sticky substance excreted by the insects. This not only tends to close the pores of the leaf, but it supports a black fungus which soon covers the entire under surface of the leaf, making it appear as though it were covered with soot. In a badly infested greenhouse the upper surface shows this fungus, but less so than the under surface.

The time required for this insect to complete all its life history stages is not more than five weeks, allowing one week's time for oviposition. It follows that an indefinite number of broods are possible, and if left unchecked their numbers may easily become most seriously destructive. Hydrocyanic acid gas is the most successful, as well as the most satisfactory, remedy. Before fumigating it is necessary to know the amount of space contained in the house; this will enable the operator to mix his chemicals properly. Hydrocyanic acid gas if used too strong, or if left in the house too long, will seriously injure the plants. It is therefore very important that the directions for treatment be followed carefully. The best proportion of cyanide, sulphuric acid, and water seems to be

1 ounce cyanide of potassium,
2 ounces commercial sulphuric acid,
4 ounces water.

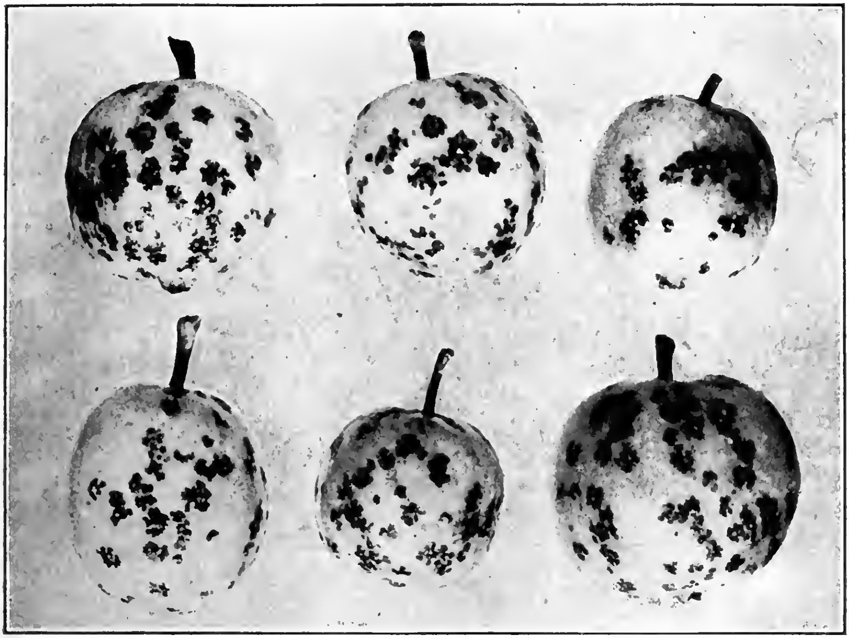
The water should be poured into the receiving vessel first; then the acid should be added; then the cyanide as directed more fully below. *Pour the acid into the water; never pour the water into the acid.* In our experiments we used 1 ounce of cyanide to 400 cubic feet of space, and left the house closed but *nine* minutes. *Do not expose the plants to the gas longer than this.*—(Bul. 100 New Hamp. Exp. Sta.)

The Greenhouse Leaf-Tyer.—The insect may include in its menu almost any soft-leaved greenhouse plant. In the horticultural greenhouses here, it has been especially troublesome on lettuce, sweet peas, clover, parsley, cinerarias, chrysanthemums, geraniums, strawberries and cucumbers. The caterpillars usually work on the undersides of the leaves eating over irregular areas through to, but leaving the upper skin of the leaf. Similar work is done on other thick-leaved plants, like chrysanthemums and geraniums. The thin leaves of lettuce and parsley were eaten entire, while those of sweet peas and clover were skeletonized. Often the caterpillars exhibit their rolling or tying habits and two or three small leaves may be loosely tied together with silken threads, or on larger leaves silken bands are stretched across from one large vein to another, often resulting in partially folding or kinking the leaf; the caterpillar works under the silken bands in the fold. But many times there is no tying or rolling of the leaves, the caterpillar feeding openly on the underside under a few silken strands.

The adult insect is a small rusty-brown moth with somewhat obscure blackish markings on its front wings. In greenhouses the moths may be found resting during the day in angles made by the framework, and also out of sight on the plants. They fly readily when disturbed, but soon alight and rapidly run to the underside of the object on which they alight; when cold, they are less active, and thus more easily captured. They are attracted by lights.

The much flattened, elliptical, translucent eggs of the insect are closely attached to the undersides of the leaves in clusters of from eight to twelve, often two to four of which may overlap. The egg shell is finely reticulated, and is apparently not easily penetrated by liquids as caterpillars were reared from eggs which had been soaked in water for two days. Observations indicate that the egg-stage lasts about twelve days.

The full-grown caterpillar or larva is about three-fourths of an inch long, and of a general translucent greenish-white color; its head is of a dark straw color with darker mottlings, and there is a small, conspicuous black spot in the center of each half of the prothoracic shield. A narrow dark green stripe extends medially along the back, bordered on each side by a much wider, light greenish-white stripe;



BEN DAVIS APPLES; BLOTCH ON YOUNG FRUIT. DEPT. OF AGR.

(See page 458)

YORK IMPERIAL APPLE TREE SPRAYED WITH SELF BOILED LIME SULPHUR, V[illegible]
DEPT. OF AGR.

there are five pairs of pro-legs, the last pair projecting behind when the larva is at rest.

The caterpillars are about twenty days in getting their growth and shed their skins three times or pass through four stages during this period. Usually they move about but little, almost completely devouring one leaf before going to another. When touched, however, they are very active, wriggling quickly backward or forward.

When full grown the caterpillar folds in a lobe of the leaf and fastens it securely with silk; if the leaf is not lobed, the caterpillar will eat into it to loosen a piece which it then folds over. In either case the inside of the folded portion is thoroughly lined with silk. In this cocoon, the caterpillar transforms in a day or two into the third stage of the insect's life—the pupa or quiescent stage. The pupa is not quite half an inch long and is dark brown in color, lighter on the venter. The pupal stage lasted from twelve to seventeen days. The emergence of the moth then completed the life-cycle of the insect as observed in the greenhouses here. As the life-cycle may be passed through in from forty-four to fifty days, and as the insect breeds freely during the whole year in greenhouses, seven or eight generations may occur indoors.

With so many broods in a year, this insect is capable of doing much damage even to outdoor crops. When once thoroughly established in a greenhouse it will ruin thousands of soft-leaved plants unless it is persistently watched and fought.

The only method by which they have thus far been able to materially reduce the numbers of the pest in the Horticultural greenhouses is by hand-picking or killing. All hands are constantly on the lookout for signs of the insect and every specimen of moth, caterpillar or pupa found is at once killed. Forty of the moths have been killed in one morning in the houses, and scarcely a day passes that many of the leaf-tyers are not thus sent to their "happy hunting grounds." The moths are quite easily caught or crushed in their resting places and the caterpillars are readily located by their work on the leaves, and by a constant warfare of this kind the pest can be kept below the danger limit, but, as those who have had experience know, the few remaining stragglers can often annoy the lover of perfect-leaved, symmetrical plants, more than a host of plant-lice, mealy-bugs, or scale insects.—(A[2] Bul. 190 Cornell E. S.)

Bud Gnat of Roses.—Occasionally the buds of roses in greenhouses turn black, due to the presence therein of a footless orange-colored grub. This is the larva of a small gnat which works between the sepals and the bud. It is usually kept under control by the fumigations with tobacco.

The Gad Fly of Violets.—This pest is the most destructive insect affecting the violet. The adult is a small fly or gnat, which develops from a yellow-colored grub, that feeds in the crowns of the plants. The worm folds the young tender leaves, stunting the plant and causing it to send out side crowns and suckers, which do not develop high-grade flowers.

Fumigation with hydrocyanic acid gas as usually practiced for the control of the red spider is an efficient remedy.—(Bul. 22 New Cir. U. S. D. A., D. E.)

PESTS OF DOORYARD PLANTS.

The house-wife's flower-bed, rose bushes, sweet peas and other plants which she may attempt to grow near the house may frequently suffer from insect attack. Plant-lice, leaf-hoppers, the so-called "red spider," and the small, green slugs or "worms," all often occur on roses at the same time. Sweet peas are often ruined by the red spider; asters and the buds of dahlias and similar plants are often "blighted" by the punctures of the little tarnished plant-bug; and the blossoms of asters, chrysanthemums and the like sometimes swarm with blister-beetles.

Leaf-hoppers are the small, whitish, active little creatures that often swarm on the under sides of the leaves of roses, leaping into the air upon the slightest disturbance of the bush. They suck their food from the leaves like plant-lice. The green slugs eat the leaves and finally transform into small, black sawflies. The tarnished plant-bug is another sucking insect, which abounds almost everywhere that plants of any kind grow. The blister-beetles are quite large, slender, blackish beetles which eat blossoms and soon render them unsightly.

The housewife should be equipped with one of the smaller sprayers, like a hand-atomizer or a bucket-pump. With one of these machines loaded with a whale-oil soap solution, kerosene emulsion or tobacco decoction, the plant-lice, leaf-hoppers and "red spiders" can be easily controlled by several applications at intervals of a week or so. If good water pressure is available, these insects can usually be kept in check with a forceful water-spray frequently applied. As the slugs are chewing insects, they can be easily fed a dose of poison by either spraying on a Paris green mixture (one pound in 150 gallons of water) or by dusting on hellebore. No method has yet been devised for preventing the tarnished plant-bug from blighting the buds of flowering plants. This insect breeds in such large numbers in nearby grass-lands that fresh recruits are always at hand. The simplest and surest method of stopping the depredations of blister-beetles is either to hand-pick or knock them off into pans of kerosene.—(New Series I No. 2 Cornell Reading Course for Farmers' Wives.)

The Rose Scale.—This is a snow-white scale about one-tenth of an inch in diameter, somewhat irregular in outline; on the whole, broadly oval in contour. On a badly infested twig there will be seen, besides these broad scales, many of lesser size—not quite so white, more oval in form, and with the yellowish band or point projecting beyond the scale line. We also find a series of much narrower scales, ridged in the center, and these cover the male, all the broad scales being females in every instance. This species attacks rose, blackberry and raspberry, the rose being the most common host. It has a distinct preference for plants grown in the shade, and particularly where, besides being shady, the ground is also damp.

Hibernation may be in any stage from the egg to the gravid female, all stages being found during the winter months. By the beginning of March few eggs remain, the larvæ are generally covered and the majority of all the insects are females ready to reproduce. During May and June eggs and active larvæ are most commonly present, and there seems to be a continuous breeding throughout the season without a regular division into broods.

The larvæ are dull orange in color, with well defined black eye spots and well marked antennæ and legs. Unlike most other scale insects this larva, when it has once set, does not immediately cover itself with a waxy secretion. It may remain for several days entirely naked, and scale growth is both irregular and slow. If there are only a few of the insects and the plants are vigorous, no perceptible harm will be done; if the plants are well set with fruit or flowers and not too well fed, the scales sometimes cause considerable injury.

In the garden all that is usually necessary to control this insect is to admit light and air and to cut out the worst infested shoots. Rose plants can, as a rule, be entirely cleaned in this way, and blackberry and raspberry plants need little more. Judicious trimming in winter will be all that is necessary in most cases.

Sometimes rose plants are so situated that cutting back is not desirable and then a resort to insecticides is necessary. Winter applications are best and any of the winter washes recommended for the pernicious scale will answer. The covering is thicker than that of the scurfy scale; but is not so resistant as that of the other species here mentioned. As the insects pass the winter in all stages, one application may not be sufficient, and it will be better to make another toward the latter part of May, when those forms that were in the egg stage and most probably escaped will be in a condition to be reached by insecticides.—(Bul. 181 N. J. E. S.)

The Rosebud Curculio.—This occurs very commonly on wild and cultivated roses in Montana. The beetles are rather shy when discovered, and though their movements are not quick, they soon disappear under a leaf or stem when a person approaches. In common with many other insects, they have the habit of drawing in their legs when in danger and allowing themselves to drop to the earth, where they remain motionless for a short time, or until the danger has passed. This is doubtless an effective means of protection against natural enemies.

The colors found on the beetle are red and black. The wing covers, which make up the greater part of the upper surface of the body, and the thorax (prothorax) are red, while the head, including the beak or snout, the antennæ, the legs, and the entire under surface of the body are black.

The beak or snout is long and slender. The antennæ are club-shaped and are attached near the middle of the snout, one on each side. The mouth parts are situated on the extreme end of the beak, and are made up of a number of pieces, the most formidable of which are the mandibles, which are toothed on both the inner and outer edge. Exclusive of the beak the beetle measures a little less than one-fourth of an inch in length.

The injuries for which the species is responsible are done by the adult or beetle, and so far as is known by the writer, the larva, though it feeds in the fruit of the rose, does no harm to the bushes in any way. The principal injury accomplished by the beetle is done by boring small, deep holes into the buds. Many holes are often bored into a single bud. Though such a bud may open, the resulting rose is of no value. Other buds cease to develop when eaten into and soon wither and dry up. The beetles also bore holes into the stems of the roses at right angles to the axis. Buds affected in this way wilt, and hang from the stems, and later dry.

We have not been able to see any particular significance in the boring of holes into the stems, though when we began the studies it was thought possible that the buds were caused to wilt and dry for the purpose of preparing a suitable food for the young. Though very many such buds have been broken open and examined, we have never found a larva feeding in one.

The injuries are scarcely less serious and extensive than those of the rose chafer, in the Eastern States, and a number of cases have come under the writer's attention in which persons have given up an attempt to grow roses on account of the injuries of this insect. We have received no reports of injury by this insect on green-house roses. The species is a native one and has been found by the writer on wild roses far into the mountains in Montana.

The beetles appear on the bushes early in June and continue until the latter part of August. The eggs are deposited in various places. Most of those found by the writer were in the buds, either in the unexpanded petals or in the young fruit. One egg was found in the tender extremity of a new cane and one in a Cynipid gall. In all cases the eggs were found in the holes made with the beak, and were placed well down in the holes, below the surface. They are semi-transparent and almost colorless. The eggs hatch in a few days, probably about a week or ten days. We have never been able to find larvæ except in the rose hip or fruit, and this is doubtless the normal place for their development.

They feed upon the seeds which fill the greater part of the cavity of the fruit. The fleshy coating of the fruit is not eaten so far as we have observed. Examination of a fruit containing a nearly full-grown larva shows a part or all of the seeds excavated to mere shells and the body of the larva buried in a mass of waste and excrement. Such a fruit shows a blackened scar on the side which marks the spot where the parent beetle bored in to deposit the egg. The larva or grub is yellowish white with a rosy tint and instead of being straight has the back arched. It has no legs. In many cases hand picking is all that is necessary to get relief from the injuries caused by this insect.

In a previous paragraph we have mentioned the fact that when disturbed the beetles drop to the ground. Taking advantage of this one can catch the beetles by holding a hand, or better, a pan containing kerosene underneath and causing the beetles to drop. Under some conditions hand picking is a futile measure. When the cultivated roses to be protected are in the vicinity of wild roses which breed the beetles year after year, it will probably be useless to attempt hand picking. Under some circumstances it may be profitable to destroy wild roses that furnish a breeding place. In general, however, it should be borne in mind that the beetles fly over a considerable distance and that until fence corners and waste lands of the surrounding country are cleaned of the native roses, more or less trouble will always be experienced. It is said that a spray of Paris green will kill the beetles.—(Mont. E. S. B. 46.)

The Rose Slugs.—Roses grown in gardens in the United States are attacked by three species of sawflies which live, in their larval stages, on the foliage, skeletonizing the leaves or cutting out holes of variable size and greatly disfiguring the plants. The larvæ, popularly known as rose slugs, slugworms and roseworms, have been classified as the American rose slug, the bristly roseworm, and the coiled or curled roseworm, respectively. For the sake of uniformity they may all be called rose slugs. The first of these, as its common name indicates, is native to America; the other two are evidently accidental introductions from Europe, as they are now common to both hemispheres. As with most other sawflies, they are found more abundantly in the North, but are quite troublesome as far southward as Maryland and Kansas. They practically confine their depredations to the flower garden, and roses are the only plants that are seriously damaged by them. Injury is due entirely to the larvæ, and the three species, each representing a distinct genus, differ considerably in appearance in all stages, as also in their life history and manner of work.

*The American Rose Slug.**—The sawfly which produces the American rose slug is a four-winged bee-like insect of a deep shining black color, with translucent smoky wings having dark-brown veins and a brown spot near the middle of the edge of the forewings. The wing expanse of the female is about two-fifths of an inch and the length of the body is fully one-fifth of an inch. The male is a little smaller.

The larva or slug when full grown is about one-third of an inch long and sluglike, with the thoracic joints enlarged. The body is soft and delicate, but not gelatinous and slimy, as is the case with some sawfly larvæ—for example, the pear slug. The color is green above and yellowish on the lower surface. The head is small, oval, and yellowish, and has a black spot on each side inclosing the eye.

The parent sawflies issue from the earth at varying times from about the 1st of April, or earlier in the District of Columbia, to the third week in May, or, according to Harris, until the middle of June in Massachusetts, beginning at about the time when the roses first unfold their leaves and continuing until they are in full leaf. During this period pairing takes place and eggs are deposited. The females are particularly sluggish in the cool of morning and are not often seen in flight, resting during the greater part of the day on the leaves. When disturbed they draw up their legs and fall to the ground. The

* See illustration on page 555.

males, however, are quite lively, flying from one rose bush to another and hovering around their less active partners.

The female in depositing her eggs turns a little to one side, unsheaths her delicate saw-like ovipositor, and thrusts it between the two cuticles of a leaf, depositing a single egg in each incision. The egg is of circular outline, much flattened, and measures about one-twentieth of an inch in diameter. Hatching begins in from ten days to two weeks after the eggs are deposited. The larvæ or slugs are to be found at work as early as the 1st of May in the District of Columbia, but their appearance in numbers is seldom noticed until the second or third week of that month. Feeding takes place chiefly at night, and always on the upper surface of the leaves, the lower surface, ribs, and midribs remaining as a skeleton. The leaves are practically always skeletonized, not eaten into as in the case of the other two rose slugs, except when the larvæ are nearly grown. During the daytime the larva usually rests concealed on the under surface of a leaf.

Sometimes the larvæ are so abundant that not a leaf on a bush is spared, and the foliage looks as though it had been scorched by fire, and eventually drops off. The larvæ are stated to be between two and three weeks in attaining their growth. They cast their skins several times, leaving them fastened to the leaves. After the last molting they lose their greenish hue and become opaque yellowish. They then descend into the earth to a depth of an inch or more, and each constructs for final transformation a somewhat fragile oval cell or cocoon coated with particles of earth. Here the insect remains as larva until the following spring, when it transforms to pupa shortly before issuance in May. The species is single-brooded, in which respect it resembles many other species of sawflies.

This rose slug and the others which will be discussed are quite easily controlled by several different methods. A strong stream of water directed upon the plants from different sides by an ordinary garden hose or large syringe, if applied every day or two, will soon rid rosebushes of the pest. This is at the same time an excellent remedy for rose aphides or plant-lice. The insects are dislodged, fall to the ground, and are unable to reinfest the bushes.

Where it is possible to apply them without danger of poisoning human beings or disfiguring the plants for ornament, different poisonous preparations are useful. Of these, Paris green, either dry or in solution, arsenate of lead, and white hellebore are good remedies. Paris green is best used as a spray in the proportion of an ounce to a gallon of water. Applied dry, it is mixed with 20 parts of flour or similar diluent and puffed on the plants by means of a powder bellows. For use in large gardens, however, the poison is employed at the rate of 1 pound to from 75 to 125 gallons of water, lime being added in about the same proportion as Paris green to prevent scorching. For properly mixing and applying this insecticide a sprayer of good quality should be used. Sprinkling with a watering pot or with a whisk broom will not answer the purpose and is, moreover, dangerous to tender foliage. The Paris green is first mixed with a small quantity of water into a fine paste before the bulk of water is added and should be churned in the sprayer or force pump until thoroughly blended. The resulting mixture, being a mechanical one, is not constant and the arsenical sinks to the bottom. The solution should therefore be constantly stirred while being applied in order that an even application may be made. In applying an arsenical spray an effort should be made to reach all of the leaves, which may be accomplished by spraying from two sides. Two or three applications will suffice for the spring generation of rose slugs. Scheele's green and some other arsenicals can be used instead of Paris green.

A still more valuable insecticide for such insects as rose slugs and other leaf feeders is arsenate of lead, but its use is open to the objection that it discolors the leafage, leaving a white deposit, which is not, however, permanent. It is applied in practically the same manner as Paris green and is a less poisonous arsenical, and, being sold in paste form, is used at a considerably greater strength—about 1 pound combined with 15 to 25 gallons of water or Bordeaux mixture. Being adhesive, it adheres more firmly to the leafage and is much less likely to produce scorching.

Hellebore is used at the rate of 1 ounce to from 2 to 3 gallons of water, and kills by contact as well as by its poisonous effects when eaten by the insect. It is less poisonous to man than an arsenical, but not so effective to leaf-feeding larvæ. It may also be applied dry mixed with about double its weight, or more, of powdered plaster or cheap flour.

When not in use the receptacles containing poisons should be plainly labeled Poison! and placed on a high shelf or in a locker out of the reach of children. Properly applied, there is no danger, in using an arsenical on ornamental plants, of poisoning human beings, or domestic animals other than rabbits or similar pets.

Oily soaps, such as fish-oil or whale-oil soap, and other soaps, and tobacco water will kill these insects, but their use is open to the objection that if applied just before or at blossoming they are apt to injure the petals of delicate flowers, and whale-oil and tobacco also leave an unpleasant odor. A neutral soap, such as castile or that used by physicians and surgeons, leaves no odor.

If rose slugs are picked off by hand upon their earliest appearance this will greatly reduce their numbers for the following year. In the adult or fly stage these insects may be easily captured by hand on cool mornings. Hand picking may be tedious, but it is effective.

If other means that have been specified have not been utilized for the suppression of the slugs, many individuals may be destroyed by frequent cultivation of the soil between the rose plants during the late summer and autumn. This has the effect of breaking up their pupal cells and otherwise disturbing the insects so as to interfere with proper hibernation.

The Bristly Rose Slug.—The bristly rose slug, called also the spiny rose slug, is the principal enemy of the rose in and near the District of Columbia, not excepting the rose-chafer. The adult of this species differs considerably from that of the American rose slug.

It is a larger insect and also a member of a different genus. The wing expanse is about one-half of an inch for the female; a little shorter for the male. The ground color is black. The antennæ are rather stout and acutely pointed, and in the male the proximal joints, or those nearest the head, are pectinate or comb-toothed, which has given rise to the specific name *pectinicornis*. The egg is white, flattened, rounded, stoutest at the anterior end, and more pointed at the opposite end. It measures about 0.8 mm. in length.

The larva or slug varies from yellowish to glaucous green, and the whole surface is quite bristly, especially at the sides, a character from which this larvæ derives its common name and which will distinguish it from the other two that feed upon the rose. The length when full grown is a little more than three-fifths of an inch and the diameter is between one-tenth and two-tenths of an inch. The pupa is grayish green, the thorax and end of the body are slightly yellowish, and the antennæ, wing-sheaths, and legs are white with a slight greenish tinge. The distribution includes the States of Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, the District of Columbia, Indiana, Illinois, and Missouri.

The bristly rose slug differs considerably from the preceding in its life economy. Its appearance at Washington, D. C., and at St. Louis, Mo., has been observed from the latter days of April to the third week of May, beginning about the time that the first rose leaves are put forth. Its eggs are inserted in the upper surface of the petiole of the leaf and are deposited in rows of three or more together. The slug in its earliest stage skeletonizes the leaves, leaving whitish blotches and small holes, but with increased growth it eats large, irregular holes in the leaf, devouring the entire substance, and frequently leaving nothing but the stronger ribs. While feeding, the slug rests in concealment on the lower surface of a leaf, and does not feed on the upper surface, as does the American rose slug. Upon attaining full growth it does not, like the latter, abandon the plant upon which it has fed until the final generation. Indications are that there may be three and, in some seasons in its southernmost range, perhaps four generations produced each year, larvæ occurring as early as the 1st of May and as late as the 1st of November. The larvæ of the earlier generations spin their cocoons, which are composed partly of silk and partly of a glutinous substance, upon the lower surface of the leaves, or on twigs or near-by objects, usually surrounding them with an irregular fringe. The last or autumn generation forms its cocoons among fallen leaves and other rubbish about the base of the rose bushes.

The same remedies advised against the American rose slug are employed against the present species, with the exception of fall cultivation, which is practically useless when applied to it, owing to the fact that the cocoons are formed upon the plants on the surface of the ground and not buried in the earth as with the preceding species. Since there are more than one generation of this slug, sprinkling with water and spraying with poisons must be repeated several times in order to produce the desired results; in short, as often as the insects reappear upon the plants, from April to October, according to locality.

The Coiled Rose Slug.—The third of the rose slugs under consideration, the coiled rose slug, is a comparatively recent importation. From the two preceding species this insect may be readily separated on account of its larger size in the adult stage. It has nearly transparent wings, and a wide band which crosses its shining black abdomen near the middle. The body is comparatively slender, and the head longer than in the other two species. The wing expanse is about five-eighths of an inch and the length of the body about three-eighths of an inch.

The larva when mature is about three-fourths of an inch long and differs notably from the other two species here considered in being perfectly smooth. It is cylindrical and tapers very slightly toward the posterior extremity. The color is metallic green above, ornamented with small white dots, and the lower surface, including the legs, is grayish white. The head is yellowish orange, with a dark brownish-black stripe down the middle. The eyes are black. The first thoracic segment is blue and the last two are gray. The larva habitually rests in the coiled or curled position, one that is never assumed by either of the other rose slugs, and it is from this habit that it derives its English name.

The coiled rose slug is credited with being double-brooded, and as it extends its range southward it will probably produce a third generation, since we know of the appearance of the worm from May to October. Eggs are deposited singly on the underside of the leaves to the observed number of from three to seven. This slug differs from the others in devouring the entire substance of a leaf, feeding along the edges with its body coiled beneath it, and when at rest remaining curled in a ball on the lower surface. Upon reaching maturity the slug deserts the leaves and bores into the pith of the stems of dead rose bushes or other available plants, and here the pupal state is passed, the fall generation hibernating to emerge the following May. At Boston, Mass., the adults have also been observed in July, this indicating the first new generation. The remedies are the same as for the American rose slug, subject, however, to the same changes as for the bristly rose slug.—(Cir. 105 U. S. D. A., B. E.)

Rose Leaf Hopper.—A whitish spotted condition of rose leaves, giving them a gray appearance, indicating the presence of numerous white insects feeding upon their lower surface, is very common. These insects represent one of many kinds of closely allied insects that infest the lower surface of the leaves of numerous plants. By means of their tiny beaks they suck the nourishment from the leaves, destroying the tissue contents at the points of injury, resulting in the spotted aspect of the upper surface. When disturbed, these insects hop to an adjacent leaf so that one needs to use a little caution in order to observe them at their work. The injury from these insects can be prevented by spraying the plants from beneath, with kerosene emulsion, or dusting them frequently with buhach or white hellebore.—(Bul. 36 Nev. Agr. Exp. Sta.)

The Canna Leaf-Roller.—Leaves infested soon become so badly eaten that they die, becoming brown and ragged, thus changing them from beautiful ornamentals to unsightly objects. Those having beds or terraces of cannas which have been dying, or browning, would do well to look for this insect in connection with the trouble, and follow the treatment herein advised if it is observed to be present.

Leaves may either be rolled up from one side, by the larvæ or, as is more frequently the case, younger leaves are fastened, before they have unrolled to any extent. The caterpillars feed within the rolled up leaves eating out the soft tissue to the epidermis of the lower surface. Rarely is the epidermis of the lower surface of the leaf eaten into, it being left usually quite intact. In the case of younger unrolled leaves, the margin of the outer leaf is firmly fastened to the roll by short silken threads. On the interior leaves of the roll the larvæ feed, usually quite consuming the parenchymatous tissue within. In other cases, fully expanded leaves are rolled up parallel to the mid-rib. This is done much after the usual manner of leaf rolling larvæ by spinning a thread from the margin of the leaf to a point farther in toward the mid-rib. Several of these cords are spun along the margin of the leaf and by their subsequent contraction, the margin is pulled over, and finally touches the leaf, thus forming a tube within which the larvæ feed. When the parenchyma within this tube is eaten out, the leaf is rolled again, the larva coming out along the lateral margin of the tube, and spinning threads from the tube to points yet nearer the mid-rib. In this way a large canna leaf may be quite rolled up. Usually but one or two larvæ occupy a single leaf. However, as many as five or six were found in a few cases.

General color of larva, yellowish white; quite transparent, so much so that in a live specimen the pulsation of the dorsal tube may be easily observed. A greenish appearance is given to the caterpillar from the green food within the alimentary canal. Head yellow; clypeus, yellowish brown; tips of mandibles, brownish-black. The adult is quite uniform light brown, varying in different specimens to lighter; lines of brownish black extend across both primaries and secondaries respectively one-third and two-thirds the length of the wing distant from its base. A small angular patch of white is found near the distal portion of the discal cell of the primaries. The canna leaf-roller can doubtless be best controlled by carefully cleaning off and burning the dead plants and trash from the beds during the winter season. By this procedure, most of the pupæ and larvæ, which pass the winter in these leaves and trash will be destroyed. The rolled up leaves should be watched for in the spring, and cut off and burned.—(Bul. 45, Fla. Exp. Sta.)

The Larger Canna Leaf-Roller.—The parent is a large, skipper butterfly with a wing expanse of 1-1¼ inches. The head is very broad, with large eyes and the body is thick and heavy. The upper surface of the head, thorax and a portion of the abdomen is thickly covered with long, olive hairs. The wings are dark brown with semi-transparent spots. The lower surface of the wings is a much lighter brown. The larva or caterpillar is semi-transparent, pale green with a dark, orange head. The pupa is pale green and semi-transparent also.

This insect is largely confined to the semi-tropical parts of the United States, and is first seen there about May. The caterpillars roll up the edges of a canna leaf and feed from the case so formed. Hand picking is the best remedy as the cases are very conspicuous. Any arsenical spray will control this pest.—(Bul. 54, U. S. D. A. B. E.)

White Grubs in an Aster Field.—The common white grubs are the larvæ of the May beetle. They feed underground for nearly three years, eating the roots of a large variety of plants. Where they are allowed to remain undisturbed for years as in grass land or where nursery stock is growing they may become numerous and will be very liable to injure the first crop planted after their old source of supply is removed. Such was the case with a field of 20,000 asters grown after nursery stock near Geneva, in which more than 10 per cent. of the plants were ruined by the grubs. The injury began to show in the latter part of July, in the wilting of the plants. On pulling these up, from one to four or more of the grubs would be found feeding at the roots. The plants were pulled up and the grubs destroyed, which was about all that it was possible to do. It is very difficult to check the insects after a field has become infested. Prevention is by far the most satisfactory. Short rotations of crops keep the land broken up and tend to restrict the numbers of the grubs, while meadows or pastures are very liable to become badly infested.—(Bul. 212 Pop. Ed. N. Y. Agr. Exp. Sta.).

INSECTS AFFECTING SHADE TREES AND ORNAMENTALS.

SCALE INSECTS.

Scale insects are among the most formidable of the pests from which the shade trees must be protected. On account of small size and protective coloration they frequently escape detection by the untrained eye until they have secured such a strong foothold that the host is permanently injured. Further, in addition to the advantage they possess by reason of the insidious nature of their attack, some are extremely resistant to remedial measures, among these being some of our most common species, such as oyster shell bark-louse, terrapin scale of the maple, etc.

The majority of the species remain fixed after the scale covering is formed. The spreading is effected by the young as they crawl about seeking a suitable place to begin feeding; as they are carried short distances by spider webs or winds; or possibly longer distances upon the feet and feathers of birds. This motile period in the history is of short duration, usually not longer than two or three days.

Insects of this order obtain their food by inserting their sharp, hair-like beaks into the tissues of the plant and drawing out the sap, hence applications of poisons are ineffective, and for all practical purposes it may be said that control methods are confined to spraying with contact insecticides during one or both of two seasons, the latter depending upon the species. Some scales are more easily destroyed by the action of a strong spray, used during the winter months, while others are susceptible to treatment with a weak spray applied during the summer months when the brood of young is appearing. The last named method, however, is useful only when the entire brood of young appear within a few days, and when the host is foliated sparsely enough to permit the spray to reach all parts of the plant.

*The Oyster-shell Bark Louse.**—(For a complete description, see Insects Affecting the Apple).—In appearance this scale is dark brown in color, shaped like an oyster shell, and is about one-eighth inch in length.

A number of plants are quite susceptible to this scale, the most common for Ohio being Carolina and Lombardy poplar, willow, horse chestnut, ash, sassafras, and red-twigged dogwood. The poplars are undoubtedly the most susceptible of all, and so injurious in fact is this scale to these trees that the authorities in Cleveland have stopped the planting of them, and wherever practicable are replacing growing trees with more desirable kinds. Spraying during the early spring with the lime-sulfur wash, or during the hatching period with kerosene emulsion or whale oil soap solution, is the remedy usually employed against this pest.

The San Jose Scale.—(For a complete description, see Insects Affecting the Apple.)—This species is almost well enough distributed and well enough known to render a description unnecessary. However, it may be stated briefly that the individual scales are very flatly conelike, with a whitish nipple at the apex; the remainder of the scale is gray or blackish and the whole is about the size of a pinhead. When occurring in large numbers on a branch it gives it a gray ashy, flaky appearance. The more common of the plants suffering seriously are as follows: juneberry, hawthorn, privet, poplar, Prunus spp., currant, apple, rose, willow, ash, lilac, osage orange and elm. A winter application of the lime-sulfur wash is the safest, most effective and cheapest remedy for this pest.

The Scurfy Bark Louse.—This insect appears in the adult stage as flat white specks upon the bark or fruit of the host. The winter is passed in the egg stage under the protecting mother scale, hatching occurring during the latter part of May or in early June. The red-twig dogwood, willows and some of the rosaceae are particularly subject to such infestation. The lime-sulphur wash applied during the winter is effective, as are also contact sprays applied at hatching time.

The Putnam Scale.—On account of similarity in general form this species is frequently mistaken for the San Jose Scale, especially when the infestation is slight and the scales immature. The superficial distinguishing features however are as follows: the scale is slightly darker in coloration; the nipple reddish; the spread less rapid; the injury less severe, and lastly the young exhibit a stronger

* See illustration on page 375.

tendency to settle about the mother, resulting in a somewhat irregular infestation. This insect occurs more commonly in the towns than in the country, and the trees most generally attacked are hard maple and linden. The maples in the parks and upon the streets in Cleveland suffer severely from this pest. The lime-sulfur is effective against this pest.

The Rose Scale.—This species resembles the scurfy bark louse, though the general appearance of the infestation as a rule is of a whiter, fluffier nature. The life history is practically the same as that of the scurfy scale, and the winter applications of the lime-sulfur wash are effective. Roses, blackberries and raspberries are most commonly attacked. *Rosa rugosa* is more severely attacked than other roses, but even with this variety, the writer has observed very few instances where the plants were killed.

The Elm Scurfy Scale.—This species occurs upon the elms and the lindens. It resembles very closely the scurfy bark louse, in fact it is quite likely that for many years it was confused with this insect. The life history is the same. In the writer's observation, however, the elm scurfy scale is not so evenly distributed over the host plant as is the scurfy, the lower side of the branches being more subject to infestation. Lime-sulfur is effective. Contact sprays applied at hatching time are effective against this species.

The Cottony Maple Scale.—During the early summer months this scale is easily detected by the presence of a white, cottony mass which the insect exudes from beneath the covering scale. Within this mass may be found the eggs, the number varying from a few hundred to two thousand. Hatching occurs during the early summer and the young migrate to the leaves or to the tender young growth, where they settle and begin feeding upon the sap of the tree. Meanwhile a thin scale covering forms over each individual, which with the growth of the insect enlarges and in time turns brown. Before the leaves fall most of the insects migrate to the branches and trunk, where they settle preparatory to passing the winter in their partially grown condition. With the coming of spring maturity is soon reached and the cottony mass already described appears.

The species prefers soft maple, though a number of other trees are subject to slight attack, among the more common being hard maple, honey locust, elm and grapevine.

Two species very closely resembling the one just described attack the hard maple; the maple leaf scale, Walsh and Riley, and the Woolly maple leaf scale. The former is found upon the leaves and the latter upon either the leaves or branches.

Natural parasites play an important part in the economy of this insect, in most seasons being sufficiently numerous to prevent serious damage. However, for some reason the natural enemies are not always successful in developing and considerable harm is done by the scale. When the insect becomes sufficiently troublesome to require attention, winter spraying with kerosene emulsion, containing from 12½ to 25 per cent. kerosene, is the remedy most commonly recommended.

The Maple Terrapin or Black Banded Scale.—(See Insects Affecting the Peach).—This insect is sharply hemispherical in form, the adult female is about one-sixteenth of an inch in diameter and the color, though variable, is of a general reddish tone with a more or less distinct blackish band near the border. One of the most distinctive characteristics, however, is the peculiar sickening odor that is especially noticeable when the well grown scales are crushed.

Soft and hard maples suffer most commonly from this pest.

In the author's experience winter applications of the stronger insecticides commonly used against scale insects have proved unsuccessful in furnishing a control, in fact the insects seemed to be little harmed by the applications. It may be found, however, that kerosene emulsion containing 20 to 22 per cent. kerosene will bring about the desired results. The hard maple is more liable to injury from the application of strong emulsion than is the soft maple.

The Elm Bark Louse.—The adult females of this insect are the most conspicuous forms. They may be seen clustered along the under side of the smaller limbs, usually beside a crack or crevice in the bark, and presenting a general resemblance to a growth of lichens. The full grown viviparous females are about 1-10 inch long just before giving birth to their young, oval in outline and with slightly pointed extremities. Each is surrounded with a white, woolly secretion, which also extends partly over the insect and thus renders its segmentation more apparent. The females become full grown in early spring and the young appear during the month of June.

What is known as the bitter elm is most subject to attack. The water elm is rarely attacked and, if so, very slightly, even when growing beside infested specimens of the former species. Prof. R. H. Pettit, of the Michigan Agricultural College, reports success from the use of the lime-sulfur wash upon the elms located upon the college grounds. It is quite likely that this is the most practicable and satisfactory spray to be used.

Tulip Tree Lecanium.—In cases of severe infestation the branches on which it occurs appear irregularly knotted. Occasionally, fatal results are reported to follow its attack, but in the writer's experience he has never seen a tree killed or severely injured by it. However, the large fleshy scales surely consume considerable of the tree's sap and thus harm it to a certain extent.

The Pine Leaf Scale.—This is a small, elongated, snow-white scale, at the narrow end of which is attached a small yellow pellicle. It is found attached to the leaves of the pine. The winter is passed in the egg stage. Two broods occur annually, one in early summer and the other during the fall.—(Bul. 194, Ohio E. S.)

A weak kerosene emulsion was applied at the time the first brood was emerging and a very dilute solution of whale oil soap at the time the smaller fall brood appeared. As a result the trees were almost completely cleared of the pest, and additional treatments have not been found necessary thus far.

The Golden Oak Scale.—The scale is easily determined on account of a yellowish-green golden color and because it causes a slight abnormal growth upon the twig, thus presenting the appearance of being partially imbedded in the bark. Although alive, the trees infested were not healthy, the bark being very rough and uneven and seemingly only partially able to fulfill its duties. Kerosene emulsion is an effective remedy when applied during the hatching period.

Pit-Making Oak Scale.—This scale is circular, usually greenish-yellow in color, and has a glassy appearance. It forms a pit or depression in the bark where it is situated, and it is about 2 mm. in diameter. This species has been sent to the Station several times on English oak, *Quercus robur,* though it is known to attack other oaks. Kerosene emulsion and whale oil soap have been used as a spray with good results in destroying this insect.

Oak Gall Scale.—A globular gall-like scale found on oak twigs. It is grey, about as high as long, and slightly broader than its length, which is about one-fourth of an inch. There is a longitudinal dorsal furrow or constriction.

Euonymus Scale.—The euonymus scale resembles the scurfy scale, but the females are somewhat smaller and darker in color. It passes the winter in the egg stage, and the different species of *Euonymus* and the orange are attacked.—(Fifth Rept. Entomologist Conn. Agr. Exp. Sta.)

The Pine Bark Aphid.—Though not a scale, this insect may logically be considered here, as its appearance is much the same as that of some of the scales and the control methods are similar. The adults may be seen as collected in thick, white, floculent masses upon the base of the pines. The pest is subject to the action of contact sprays, according to Dr. E. B. Southwick, Entomologist of the New York parks, the stiff sprays being effectual.

The Elm Leaf-Louse.—On some bright day in October the air will seem filled with myriads of tiny, woolly, blue-black insects, slowly flying to the elms and alders. Gradually they alight and start an upward procession, crawling up the trunk. By evening the trunk of the tree will be covered with insects. Another day and none will be seen, but the ground at the base is covered with their spent bodies. This host of plant lice fly to the elms to give birth to tiny yellowish young, which are the only sexual generation of the year. The yellow lice crawl into cracks of the bark where each lays a single egg. It is in this egg stage that the winter is passed.

When the trees leaf out in the spring the eggs hatch. The young plant lice crawl out on the branches and each selects a leaf. As a result of the insect's feeding the leaf becomes swollen and curled. Within this leaf retreat the louse gives birth to many young, so that during early summer curled leaves will contain several dozen individuals of various ages. At this stage a disagreeable amount of sticky honey dew is secreted, which falls to the sidewalks in drops. In July winged individuals appear in the colony and soon after they fly away to some unknown plant. The remainder of the summer is spent away from the elm, until the remarkable migration of autumn recalls the pest.

Eight infested elms were sprayed experimentally at Pullman. As a result the insect was checked, but in no case was it completely exterminated. The sulphur-lime wash gave the best satisfaction. It is recommended that trees infested with the leaf-louse be sprayed during the winter with the sulphur-lime wash before the buds burst in the spring. Attention should be given to the innermost crevices of the trunk and larger branches as it is in such places that the eggs are most apt to withstand the rigors of winter. The sulphur-lime wash is a slow poison. Its effectiveness continues for many weeks after its application.

From this outline of the life history it will appear that the leaf-louse does not live over from year to year on the elm, but that trees become infested only by the autumnal migration. Should the winter spray of sulphur-lime not be given, as is sometimes unavoidable, owing to the proximity of painted buildings, it will be necessary to spray with kerosene emulsion as soon as the trees are in leaf, and before the leaves start to curl. After the leaves have curled it is impossible to reach the louse. Trees affected year after year become dwarfed and stunted, and are entirely valueless as ornamental shade trees.—(Bul. 74, Wash. E. S.)

The Boxelder Plant-Bug.—This is a plant-bug found throughout the summer on boxelder. When full grown, it is nearly half an inch in length, of a dark gray color, and marked with red. In its earlier stages the red predominates, that being the color of the exposed body. It breeds frequently in enormous numbers upon the boxelder, becoming more numerous in the autumn than at other seasons. The bugs congregate in groups upon the trunks of these trees, and migrate in search of hibernating quarters to fences and the sides of houses, frequently entering houses and other buildings and stowing themselves away for the winter in protected places. They suck the juices of the leaves and more tender growth of the boxelder tree, and have been reported as damaging fruit, such as peaches, plums, and apples.—(Cir. 28, Second Series U. S. D. A., B. E.)

In 1880 the insect was known from Colorado, Arizona, California, Kansas, Missouri, Utah, and Mexico. Prof. E. A. Popenoe, writing in 1880, recorded its abundance upon boxelder at Manhattan, Kans. Dr. J. A. Lintner, in 1887, showed that it had not been recorded west of the Mississippi River or north of Missouri. In 1881, however, it had been received at this office from Sioux City, Iowa, from Mr. D. H. Talbot, who, writing under date of November 2, 1881, stated that it was very numerous that autumn.

During the winter the adult insect hibernates in all sorts of sheltered localities. It is especially abundant in fences, crevices of stone walls, and in the angles of stone buildings, on the south side of which it is reported to appear singly and in clusters upon every

THE PEACH-BORER AND ITS WORK. FIG. 1. EXUDATION OF GUM AT BASE OF INFESTED TREE. FIG. 2. THE "BORER" AND ITS COCOON AT ROOT CROWN OF TWO YEAR OLD PEACH TREE. DEPT. OF AGR.

(See page 51.)

warm day during the season. When spring opens and the buds of the boxelder begin to burst the bugs scatter from their hibernating places and seek their food plant. The eggs are laid normally in the crevices of the bark of the food plant, but the instinct of the mother bug is by no means true, since she will oviposit in almost any situation, frequently even laying eggs in her hibernating quarters. Few of the young hatching from such eggs will ever reach a suitable tree. In Kansas the first adults begin to appear after midsummer and at this time bugs of all sizes begin to congregate in lines up and down the trunks and branches of the trees. According to Professor Popenoe they may frequently be seen crowding in a broad line extending from the ground up to the secondary branches, in a company including larvæ of all sizes, pupæ, and fully matured individuals. When the leaves drop, practically all are full grown and they fly away in search of winter quarters. They feed upon a number of different plants, preferring, however, the boxelder. When they fly into greenhouses they occasionally damage the growing plants in the winter time. They are most frequently sent to economic entomologists with accounts of their fall congregating and also with tales of congregating in houses which they have entered. They are said even to have entered the beds, and one or two accounts have been sent in to the effect that they bite human beings, like bedbugs.

Spraying the trees in the early part of the season with kerosene emulsion will result in the death of the majority of the immature individuals. When they crowd together in the autumn upon the trunks of the trees they can be readily destroyed with hot water or may be swept *en masse* into kerosene pans. A little industrious work at this time of the year will reduce the numbers of the insect so greatly that little damage need be feared from them the following season.

The White Marked Tussock Moth.—(See insects affecting the apple.)—Two broods occur each season, the young larvæ of the first appearing soon after the leaves are well out upon the majority of the shade trees. The winter is passed in the egg stage. The newly hatched larva feeds for a time upon the epidermis of the lower side of the leaf but as it grows older and stronger more of the leaf is eaten until by the time it is full grown all but the midrib and larger veins are devoured. The principal hosts for this species are lindens, horse chestnuts and elms.

As a general specific measure to be used in combating this pest, the author believes there is nothing more effective and practical than collecting or treating the egg masses during the winter months and keeping the trees banded with tanglefoot from the middle of June until the first killing frost. This measure is especially commendable for individual operations as the cost would not be excessive to hire nimble workmen to climb the trees and destroy the egg-masses. It would only remain to keep the bands in good working order. If the work of destroying the cocoons is thoroughly done and the trees so treated are not close enough to neighboring trees so that the young caterpillars are able to span the distance with their webs, there is no reason why careful banding alone should not keep the trees free of this pest. If impossible to collect the egg masses, spraying with arsenicals is next in order but it too should be supplemented with banding and the mixture should be applied while the larvæ are young.

The Forest Tent Caterpillar.—During the last half century there have been occasional severe outbreaks of this insect in widely separated sections of the United States, the hard maple being the principal sufferer in the north.

The eggs are deposited in late summer, usually upon the lower branches of the tree, though they sometimes may be found upon the topmost twigs. They are placed in belts of about 150 each surrounding small twigs. After the egg is deposited, the larva develops within the egg-shell, but does not break through until the following spring, about the time the leaves are appearing. As the larvæ feed and develop, they do not spin a sheltering web as do some of the other leaf-feeding caterpillars, but, as they pass up and down the limbs of the tree, they spin a silken thread behind them, which after many passages becomes a silken path. When not feeding upon the leaves they rest in clusters upon the limbs and trunk of the tree. They also take this position to shed their skins.

The full grown caterpillar is about two inches in length and is characteristically marked with a blue head and a row of diamond shaped spots down the middle of the back. The cocoons are spun in any sheltered position, such as among crumpled leaves on or under the tree, in crevices of the bark and of fence-posts, etc. They are composed of the hairs from the insect's body, silken threads, and a liquid which the caterpillar ejects, the latter giving the mass a yellow, powdery appearance. The adult is a brown moth, bearing a darker colored band across each fore-wing, almost parallel to the outer border. They fly mostly at night. Probably the best method of control is spraying with arsenicals at the time the larvæ appear. As with the tussock moth it will probably be of advantage to band to prevent reinfestation.

The Fall Web Worm.—(See insects affecting the apple.)—The distinguishing characteristic of this insect is seen in the large unsightly webs occuring most commonly upon wild cherry during the late summer. Upon critical examination, it is seen that the webs contain a quantity of hairy larvæ which feed upon the more or less browned leaves of the twigs enclosed. This discoloration results from the insect's eating the softer portions of the leaves causing the remainder to die. Occasionally, as the larvæ approach maturity, the food supply is exhausted within the web and they wander to adjoining twigs. The pupal stage is passed in a thin cocoon, usually located in trash on the surface of the ground or just below the surface. Both sexes are winged moths, white, or white dotted with black. The eggs are deposited upon the leaves.

Because of the conspicuous web, one of the common methods used in combating this pest is clipping the twigs from the tree to which the masses are attached and destroying them. This, however, involves a loss of a part of the tree and for this reason it is preferable, where possible, to spray with arsenicals when the young caterpillars are known to be emerging. This occurs during the month of June.

The Bag or Basket Worm.—Insects of the class to which the one under present consideration belongs, derive their popular name from the curious bag or basket which is constructed during the larval stage. Soon after the larva is hatched it constructs for itself a silken sack, smooth inside, while to the outside are attached portions of bark, leaf tissue, leaf petioles, etc. From the open end of the bag the larva protrudes its head and fore legs, and thus walks about at will, dragging its home with it. To one unaccustomed to the sight it is indeed a surprise when the curious semi-shapely bundle of trash that has attracted his attention, suddenly develops life and moves away.

As the enclosed larva grows, the bag is enlarged from time to time by additions to the open end. Upon reaching maturity the larva binds its case to a limb and pupates. At the end of the pupal stage the males emerge and fly about, while the females, being wingless, oviposit within their old cases and afterwards wriggle out to fall upon the ground and die. The winter is passed in the egg stage.

Probably the simplest and most effective of the methods to be used in combating this pest is the collecting of the conspicuous bags during the winter, thus destroying the eggs; followed by the application of mechanical barriers placed around the trunk of the tree, to prevent it from being reinfested by larvæ wandering from other sources. Another remedy applicable during the summer season when the larvæ are feeding is spraying with arsenicals.

The Brown Tail Moth.—This species occurs only in the New England States at present, but unless something unforeseen happens it will be only a matter of time until it spreads. The insect has two features peculiar to it which render its separation from other insects comparatively easy. The first is the presence of a tuft of brown hair on the tips of the abdomens of the moths of both sexes, and the second is the position in which the webs are spun, namely, upon the tips of the branches.

The female moth is white in color with the exception of the brown marking already described, and measures 1¾ inches across her spread wings. The male is smaller, having a wing expanse of 1¼ inches, and the general white of the wings is broken with a few black spots. The brown tuft on the abdomen is smaller and darker in color than that of the female. The moths fly during July, and during this season the eggs are deposited in masses on the under sides of the leaves. From 200 to 300 are clustered together and are then covered with the brown hairs from the tip of the abdomen of the female.

Upon hatching, the young feed gregariously upon the surface of the leaf, spinning a covering web as they go. They soon begin the preparation of their winter nest by drawing a few leaves together and lining them with silk, and binding the whole tightly to the twigs. The winter is passed in the immature larval condition within the protection of the soil.

Early in the spring the caterpillars emerge and if the leaves have not started, begin feeding upon the swelling buds. During the spring they continue their work, completely stripping the tree in cases of severe attack. One brood occurs annually.

When full grown the caterpillars are 1½ inches long. They are dark brown with a sprinkling of orange. Long, fine, reddish hairs cover the body, and a row of conspicuous white hairs runs along each side. Like the caterpillars of the tussock and gypsy moths, they bear bright red eversible tubercles on the top of the sixth and seventh abdominal segments.

Besides doing great injury to the trees in badly infested districts, the caterpillars are equally obnoxious because of the poisoning effect the spines from the hairs of their bodies have upon human flesh. Contact with the insect's body, with cast skins as they are blown about, with the cocoons or with clothing in which the spines have gained access, may cause the characteristic irritating eruptions.

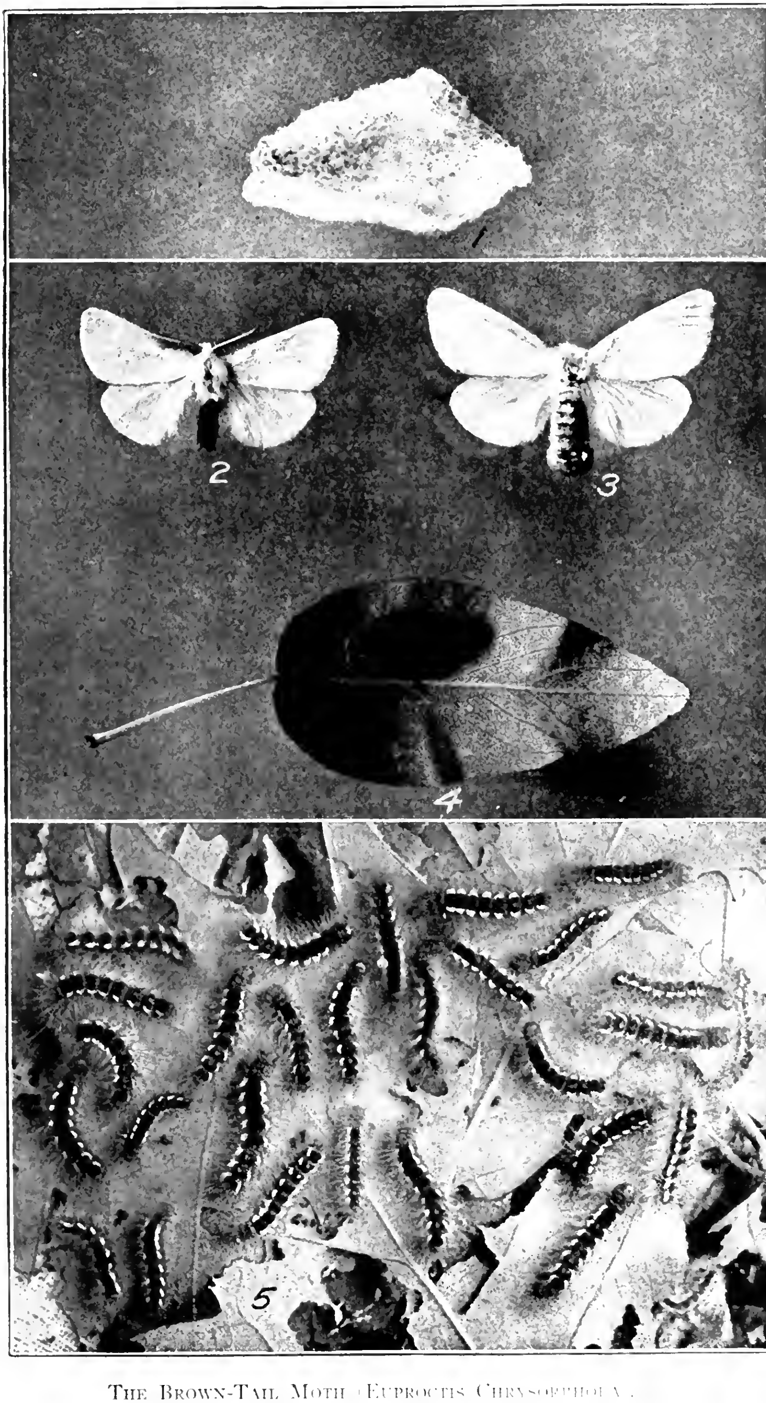
The cocoons are placed upon the leaves or in some sheltered position. They are lightly covered with the brown hairs from the tip of the female abdomen. As to food plants, according to Dr. Felt, the insect feeds upon such fruit trees as the pear, apple, plum, and cherry, and upon the following forest trees: oak, maple and elm.

The remedial measures are comparatively simple, consisting of the collecting and destroying of the conspicuous winter nests. Spraying with arsenicals is also to be relied upon, but the former is preferable because of the smaller expense involved.

The Gypsy Moth.—It was introduced into Medford, Mass., in 1868 or 1869, but did not develop in excessive numbers until 1889, when the attacks became very severe in the locality of its introduction.

At that time the state of Massachusetts began making annual appropriations for the purpose of combating the pest and during the nine years following over $1,000,000 was expended. During that time the insect spread slowly, and since 1899, when the appropriations were discontinued, more rapidly, so that at the present time a considerable area of Massachusetts is infested, and the infestation has spread to at least one of the neighboring states (Rhode Island).

The eggs of this insect are deposited usually in round or oval patches on a piece of bark and then covered with the buff-colored scales from the underside of the female's abdomen. A completed egg-mass looks very much like a small piece of sponge. The egg-mass may be found on stones, in tin cans, and in fact on almost any fixed object near at hand, preferably on the under surface, particularly of limbs and fence rails. The nearly globular, pale yellowish or salmon-colored eggs are about one-twentieth of an inch in diam-



THE BROWN-TAIL MOTH (EUPROCTIS CHRYSORRHOEA).
FIG. 1. COCOON. FIG. 2. MALE MOTH. FIG. 3. FEMALE MOTH. FIG. 4. EGG CLUSTER ON
LEAF; FIG. 5. CATERPILLARS (ORIGINAL. [illegible]).

eter, and there are usually 400 to 500 eggs in a cluster, though occasionally 1000 may be found in an egg mass.

The young caterpillar is slightly over one-tenth of an inch long just after it emerges from the egg. It has a black head, the body is brownish yellow and well clothed with long hairs. There is a prominent hairy tubercle on either side of the segment next the head; this gives the caterpillar a peculiar broad-headed appearance, especially in its early stages. The markings become plainer as it increases in size, and when full grown it is from 2 to 2½ inches long. This caterpillar has a double row of conspicuous warts or tubercles down its back, the eight anterior blue, the 12 remaining red, not counting the four blue ones just behind the head. Similar tubercles also occur on the sides.

The somewhat conical, dark brown pupa ranges from ¾ to 1½ inches long. It is usually found lying among a few threads and securely attached to them by its terminal spine.

The male and female moths differ markedly. The former, a slender, olive brown, black-marked creature with feather-like antennæ and having a wing spread of about 1½ inches, may be seen flying in the late afternoon and early evening in considerable numbers. The female is much heavier and lighter colored. She has a wing spread of about 2 inches and is a white or buff white color with more or less distinct black markings. The abdomen is tipped with buff. The female moth does not fly though she apparently has well developed wings.

The winter is passed in the egg-mass, which is remarkably resistant to atmospheric and other agencies. Experiments have shown that even when the egg clusters were broken up and freely exposed to the elements, the eggs were apparently not harmed, and a normal proportion of the caterpillars appeared at the usual time, which, in the vicinity of Boston, is from the last of April until the middle of June. The feeding period extends from the first of May to about the middle of July, a caterpillar requiring from about 9 to 11 weeks to complete its growth and enter the pupal stage. The young caterpillars remain on the egg clusters from one to five or more days and then commence feeding on the leaf hairs. Soon they eat out small holes in the leaves and, after the third or fourth molt, about as many feed on the edge of the leaf as eat out holes. The caterpillars are largely nocturnal, remaining in clusters on limbs and trunks, or hiding in some crevice during the day, and beginning between 7 and 8 o'clock in the evening leisurely to ascend the tree, where they feed on the foliage at intervals during the night, descending about 3 o'clock in the morning.

The larvæ transform to pupæ during the month of June, the moths appearing from the latter part of June till the latter part of July. In exceptional cases these dates may be considerably extended. Males emerge in advance of the opposite sex, and shortly afterwards the females appear, pairing takes place and egg deposition begins. The embryos are frequently well developed within the egg in two or three weeks after oviposition, but as a rule the caterpillars do not emerge till the next spring. A case is on record of eggs hatching in early September, 1895, at Woburn, Mass., but the round of life was not completed, and in this northern latitude at least, there need be little fear of two generations annually.

The insect feeds upon the foliage of practically all of the shrubs and plants grown for economic and ornamental purposes. Concerning recommendations for combating this pest, Dr. Felt has the following to say: Investigate anything that arouses a suspicion that it may be the gypsy moth, but be in no undue haste to identify the insect. It will be much more satisfactory to submit the specimens to an entomologist than to arouse unnecessary fears. There have already been several false alarms occasioned by persons with more enthusiasm than discretion, who have attempted to identify an insect with which they were unacquainted.

It would undoubtedly pay to exterminate a small colony, but in the course of time this will be impracticable. We must learn to control it on our own land. The inability of the female to fly and the conspicuousness of the egg-masses make this task relatively easy, unless the pest is allowed to escape to the woods. There, a private individual could hardly cope with the insect. The point of establishment is almost bound to be near some dwelling, and therefore the species need not be allowed to establish itself in wild land, at least for some years.

One of the most effective methods of keeping this pest under control is the careful collection and burning of the conspicuous egg-masses. This can be done most effectually in the fall, during the winter and in early spring. No ordinary fire running over the ground can be relied on to kill the eggs. The only safe way is to put them in a stove or similar fire and burn them. Creosote oil applied to the egg-mass will soak in and kill the eggs. The following preparation was used in the work against the gypsy moth: Creosote oil, 50 per cent.; carbolic acid, 10 per cent.; spirits of turpentine, 20 per cent., and 10 per cent of coal tar. The latter was added to color the compound and thus show at a glance what clusters had been treated.

The caterpillars prefer to hide during the daytime, and advantage may be taken of this habit to tie burlap bands in the middle around the tree trunks and then turn the upper portion of the burlap down over the string. The bands can be lifted daily and the caterpillars beneath killed. This method proved of such great value in the work against the gypsy moth that thousands of trees were banded during the latter part of the caterpillar season.

The larva is quite resistant to arsenical poisons, and it requires a large dose to kill it, especially when the caterpillar is nearly grown. There is probably no better poison for this pest than arsenate of lead, using at least 5 pounds to every 50 gallons. The application should be made as soon as the leaves are well grown, and then the caterpillars will be poisoned while young and most susceptible to the insecticide.

Spiny Elm Caterpillar or Mourning Cloak Butterfly.—The adult of this species is one of the butterflies quite commonly seen flying about. It is strikingly marked by the general dark-brown color of the wings being bordered by a margin of broken yellow, the whole general appearance being that of black bordered with white.

The eggs are deposited in rings around the twigs of the food plant, which for Ohio is usually willow, though elms are sometimes attacked. The full grown larva is black with a row of red spots down the back. It bears numerous long spines which in turn bear shorter branches. It measures about two inches in length. The pupal stage is passed as an unprotected chrysalid attached to some portion of the food plant. The winter is passed in the adult stage in some sheltered nook. Control methods consist in spraying with poison, or in collecting the larvæ and destroying them as they feed in clusters.

Black Walnut Caterpillar.—The general body color of the larva of this insect varies from dark brown to black, and it is clothed in long, white hairs. When disturbed it suddenly raises both ends of the body to a vertical position, holding only with the body legs. This peculiarity, in combination with its general color, renders the insect comparatively easy to distinguish. The full grown larva is about 2 inches in length. It has been observed by the writer feeding on black walnut only, though it is reported from other states as feeding upon butternut, hickory and others.

The larvæ feed in clusters on the leaves and at certain intervals travel to the trunk or larger branches of the tree for the purpose of molting, leaving a silken path as they go. They settle in a large mass to cast their skins and after the completion of the operation pass back along their well marked trail to their feeding grounds. A considerable quantity of the cast skins remains attached to the tree at the point where the cluster of larvæ rested. They again travel *en masse* when they pass to the ground to pupate.

The insects may be destroyed in great quantity while they are settled upon the trunk of the tree during their molting period, or the crop of insects for the following season may be considerably lessened by thoroughly working the ground beneath the tree during the winter months to destroy the hibernating pupæ.

The Catalpa Sphinx.—The insect is most easily detected by its work upon the leaves during the larval stage. The tiny worms may be observed feeding in rows or clusters upon the epidermis of the leaf. Later the whole leaf is eaten and in case of bad attacks the entire tree is defoliated. The larva is first of a pale yellowish-green color and bears a black horn or spine at the rear of the body. When full grown it resembles the large green tomato or tobacco worm, with the exception that the color, instead of being solid green, is green with broken black bands extending lengthwise of the body. The worms may be observed at least twice each season. Possibly there are more than two broods.

The larva pupate under the surface of the soil, the pupa proper being reddish brown, and somewhat smaller than that of the tobacco sphinx. It also lacks the peculiar "jug handle" common to the other species. The moth is of the regular sphinx type; pointed body, narrow, strong wings, large eyes, and is of a gray ashy color. The eggs are deposited in pearly masses on the under sides of the leaves. The winter is passed in the pupal stage.

Three methods of control are practicable to be used against the pest. The first is collecting the egg-masses or clusters of newly hatched larvæ. The second method is spraying with arsenicals. The third relates to the control of the species in nurseries or plantations and consists in deep plowing at the time the insects are in the pupal stage.

The Snow-White Linden Moth.—The moths are pure white, and the females are somewhat larger than the males and have thread-like antennæ, while the males possess feather-like antennæ. The front wings of the male and the female are angulated, those of the female more prominently. The eggs of the female moth are laid on the under sides of the branches—as often on the upper branches of the smaller trees, at least, as on the lower. The eggs are deposited on the branches in the latter part of June and first part of July, and remain unaffected by snow, rain, or extremes of temperature until the following April and May, nearly a year after deposition.

The eggs are about one twenty-fifth of an inch in length, barrel shaped, often more or less flattened on the sides, light olive when first deposited but later becoming darker in color, with a conspicuous ring at the free extremity. They occur in irregular masses, long and narrow if the branch is small but spread out if the surface is large.

The caterpillars vary considerably in color and markings. In general, after the first molt they become dark reddish brown, in many cases almost black, with the head and last abdominal segment red or reddish brown and quite conspicuous. The larvæ resemble the twigs of the tree on which they are feeding, and like other "measuring worms" have the habit of holding themselves erect and motionless like a broken twig. Full grown caterpillars that have had all the food they want become a little over two inches in length, but when they are crowded and the food supply limited they are often less than two inches long. During their growth the larvæ molt five times or even six times. The cocoons are very flimsy affairs and usually are made by turning over the edge of a ragged leaf and lining the inside with a thin net-like layer of silk. The larvæ infest a great variety of forest-trees, apparently somewhat preferring beech and maple. They have been found on elm, linden, chestnut, hickory, ash, apple, birch, and others.

The insect requires nearly a year to pass through its life history. In the control of this pest in shade-trees, spraying with arsenate of lead, 3 pounds to 50 gallons of water, would probably be very effective. If it ever becomes injurious to apple trees in this State, the same method of control would have to be followed. The trees should be sprayed early while the caterpillars are small, as the poison will be much more effective then.

As we have already noted, the caterpillars have the habit of suddenly dropping to the ground in great numbers when the trees are jarred. On small trees, hundreds of the caterpillars may be jarred on to sheets and then destroyed. Unfortunately, the young larvæ are not so susceptible to this kind of treatment, and if one waits until they become large much of the damage will already have been done.

The masses of eggs are very conspicuous objects and could easily be found on the branches and scraped off. In the case of small trees much good could be accomplished in this manner. On large trees it would be more difficult to collect the eggs.

In forests there seems no practicable way of controlling this pest. In case of the particular forest area mentioned at Cooks Falls, the wood is being grown for the manufacture of certain wood chemicals. In this instance it may be best to cut off the present growth of timber and use it for the distillation products before it dies as a result of the annual defoliation to which it has been subject for the past two years.—(Bul. 286, Cornell Agr. Exp. Sta.)

The Catalpa Bud Gnat.—During the early summer, the tender growing tips of the catalpa become swollen and in time blacken at the point of injury. During the early part of the season the injury is usually found 3 or 4 inches below the tip, and at a lesser distance during late summer when the tree is growing less rapidly. The tip above the injury dies. Following the death of the tip in early summer, the next node below develops one or more branches and frequently a cluster of leaves, giving the tree a bushy growth. The ultimate result after continued topping is a stunted, crooked, forked growth.

If one of the injured twigs is examined by being cut open, small, footless, yellow or white larvæ will be found. If one of these is placed on a smooth surface, it has the power to jump several inches in the air. This is accomplished by raising both ends of the body so that they almost meet above, and then with a sudden motion straightening out. The pupal stage is probably passed under the surface of the soil, as the author was unable to secure adults by placing twigs infested with the larva in cages that did not contain moist soil. With so little understood concerning the pest it is difficult to plan remedial measures. It has been suggested that cutting the infested twigs and destroying them would be of value during the summer.

The Elm Leaf Beetle.—The elm leaf beetle is well distributed in the eastern states, and now annually ruins great numbers of shade trees. The green and black striped beetles, not over ⅜ inch in length, pass the winter in the adult stage in some sheltered place. With the coming of spring they leave their shelters and begin feeding upon foliage of the elm. Soon the eggs are deposited on the under sides of the leaves and within a few days the larvæ appear.

They feed upon the undersides of the leaves, leaving the vein work and epidermis above. Soon the injured portions of the leaf die.

The grubs become full grown in from 2 to 3 weeks, or possibly longer, depending upon the weather conditions. At the conclusion of larval development the insects crawl about and either pupate in the crevices of the bark or in some nearby shelter. Often they may be seen lying helpless in considerable quantities at the base of the tree. It is quite likely that only two generations occur annually. Elms only are attacked.

The Cottonwood Leaf-Beetle.—Young Carolina poplars growing in nurseries in Kentucky are often badly damaged by the gnawing of an insect much like the willow leaf-beetle described below in size and general character, but it appears to prefer poplars to willows, though sometimes found also on willow. Both insects occur throughout the central states, but the one now under consideration appears to be the more eastern in distribution.

This beetle measures from about 0.28 to 0.34 inch in length. It is brown, with black head, the thorax brown at the sides and with a black isolated dot in this area on each side, the disc black as in the related insect. The wing covers are notably different from those of the other beetle, being here marked with short lines and dots, instead of with dots alone, of black. These dots and lines occupy much the same position, however, as the dots on the wing covers of the willow leaf-beetle, two dots being near the base, two lines near the middle, and the remaining pair, consisting of a line and a dot, placed near the tip and with the line joining a narrow black sutural edging. Beneath, the body is black, with the bases of the femora and the middle region of the tibiæ red.

Both species do their mischief here early in the season, and then disappear from the nurseries. Whether or not other broods develop during the season in other situations has not been determined. As in the other species, the adults hibernate among dead leaves, grass and rubbish.

The same treatment is to be employed as for the willow leaf-beetle, namely, spraying the attacked foliage with Paris green or arsenate of lead in water.—(Bul. 120 Ky. Agr. Exp. Sta.)

The Vagabond Gall-Louse.—The peculiar growth described below as appearing on willows as the result of attacks of mites has not been observed on poplars, but a somewhat similar, though rather more symmetrical growth, is often seen in winter at the tips of twigs of the latter. It looks at first glance like a dried up leaf, but stands perfectly rigid. This growth is found on examination to be a flat-lobed gall that has grown on the twigs during the summer as a result of the attack of a plant louse that lives within. In winter the galls are blackish, and measure an inch or more across. The insect is shining, black, soft-bodied, with delicate membranous whitish wings expanding about one-half inch. It belongs to a gall-producing group of plant lice, distinctly related with familiar species such as the rose aphis and corn plant louse. When it leaves the gall it wanders in an apparently aimless fashion, being found on a great variety of plants, a peculiarity that has suggested the common name. It is not common enough to excite alarm at present, and probably where it appears it will only be necessary to remove and burn the galls while the makers are still in them.

The Poplar Leaf-Tyer.—Carolina and Lombardy poplars, and also sometimes willows, when planted along streets and on lawns in Kentucky are badly marred by worms that appear among the leaves, which they draw together, singly, so as to make a nest, leaving openings by which they can go in and out, and then sew the petiole to the twig to keep it from becoming detached. In these swinging cases a half-dozen or more larvæ live together, and forage on the leaves near by. Generally they are not observed about the trees until August, but the adult moths emerge very early in the spring, March 18 and April 3, by my notes on rearing, and place eggs for an early spring brood that attracts no attention because of the small number of individuals occurring at this time on the trees.

Adults of this brood lay their eggs on the leaves soon after the latter unfold but my earliest record is dated June 4, when a cluster was found on the under side of a willow leaf. These eggs hatched the following night. On June 9 the young worms were one-half inch long, and in a note made at the time were described as of a yellowish green color, with relatively large black head, and black jointed legs, the body clothed with slender pale hairs. They feed gregariously at this stage, either on the upper or under surface of a leaf, spinning over themselves a light web of silk, which being unyielding causes the leaf as it grows to bend and its edges to come together, the case thus formed being made secure by additional strands of silk, and the whole finally being closely lined so as to make a snug retreat and lodging place for the worms. At first, they eat away the green substance of the leaf, leaving only the veins and veinlets, but when well grown are compelled to forage on the leaves outside the case. The larvæ of this brood become grown about June 27th, and then change to reddish brown pupæ within the cases. Adults emerge about the middle of July, and soon place eggs for the second brood. In 1893 eggs were found on poplar July 19, and hatched during the night of July 29. Larvæ generally become abundant and their injuries noticeable from August 19 to August 26.

Pupæ have been secured on various dates between and including August 7 and September 8. Adults have been secured on the dates, July 8, 15, and August 11. The last date may indicate either a third brood or represent belated individuals of the second. The winter is spent by the insect in the pupa stage.

Young fresh from the egg are pale green, with large shining black head, and numerous black dots. The double black tubercles on the fourth and eleventh body divisions are barely visible. When about one week old and two-thirds of an inch long, the general color is pale yellow, this color being disposed in narrow stripes alternating with still narrower more or less broken brown lines. The head, the jointed legs, a pair of spots on the first body division, two series of dots along each side, the two double tubercles, and a tail plate are black. Beneath, the color is uniform greenish yellow. The whole body is clothed with soft whitish hairs.

When ready to pupate the larva measures about 1.12 inch in length. It is marked with black, as already described, and is characterized especially by four longitudinal lines of bright sulphur-yellow extending along the middle of the back. The stigmata are black. The double tubercles on the fourth and eleventh body divisions are conspicuous, as is the clothing of soft whitish hairs.

This is formed within the case. It is chestnut brown, smooth, shining, somewhat darker in front, about 0.50 inch long, with a greatest diameter of 0.18 inch. The spiracles are large, elongate, the last, a mere line. At the tip of the abdomen is a slender spine, expanded at its extremity to form a minute anchor, a little hook extending outward on each side.

The adult is a rather rare moth. It is small, obscurely colored, with a wing expane in the male of 1.10 inch, the body being about 0.52 inch long, while the female is a trifle larger, measuring 1.16 inch from tip to tip of the expanded front wing, and with a length of body of about 0.56 inch. The color is dull drab, the front wings with a touch of rusty (ferruginous) near the tips and at the bases. Thorax in front with a large spot of chestnut. The front wings are oddly marked with narrow whitish lines, the most noticeable of which form a triangle the base of which is on the front margin of the wing, the apex beyond the middle of the hind margin. Two series of small dusky dots follow the outer margin of the front wing. The hind wing is crossed by a wavy line that becomes angled near the front margin. The males differ from the females in having broader antennæ, and in being provided with a conspicuous fan-shaped fringe of hairs at the tip of the abdomen.

When the trees are not large it is not a difficult matter to remove the rolled leaves by hand. Larger trees must be sprayed with Paris green, or arsenate of lead.

The Willow Leaf-Beetle.—Willows growing on lawn and in the nursery in Kentucky are almost completely denuded of foliage in the early spring months by rather sluggish grubs that when young feed in company on the green substance so as to leave finally only a brown network of veins and veinlets. The injury is widespread in the State, though generally increasing in severity for a time, then waning until scarcely noticeable and remaining so for a succession of years. Few of our insects prove more troublesome than this one when once it has become abundant.

The adult of this species is a shining brown insect of the same family as the Colorado potato beetle and the Elm Leaf-beetle. It measures from 0.24 to 0.30 inch in length. The body is elongate oval, moderately convex above, smooth, shining, the wing covers closely, finely, punctured when seen under a magnifier. The head is black, and is received in the hollowed out thorax; the antennæ are short, thickened outwardly, black at base and tip, the intermediate joints pale. Thorax black centrally, with a wide brown or red border, a black dot on each side lying contiguous to the central black area. Wing covers brown (testaceous) to flesh color, pretty constantly marked with black as follows: Two spots at the base of each wing cover; two spots at the middle of each, and a couple of contorted ones, narrowly united, near the tip. Beneath, the body is black, the legs largely black, but showing red or brown on the middle of the tibiæ. The wings are ample, and the legs, though short, are used with some address, though when disturbed the beetles are disposed to draw them up to the body and let themselves drop to the ground. At Warsaw, April 27, 1901, they were found in large numbers on young nursery trees not yet leafed out, and as one passed among them they made a constant pattering on the dead leaves on the ground.

The beetles are always abroad during April in Kentucky, beginning in the middle of the month. Larvæ have been found at Lexington May 26, and pupæ on June 1. On June 17, 1901, adults began to emerge from pupæ kept in confinement at the Station, from which it appears that the early spring brood is about two weeks ahead of that developing at the latitude of Central Illinois, where according to Professor Forbes pupation began on July 1, and the first adults emerged on July 3. The eggs are placed in clusters attached by their ends to the leaves. They are yellow, smooth and about 0.056 inch long.

The grubs are variable in color with age, from yellow to blackish; have three rather strong pairs of jointed legs, and at the tip of the body are provided with an adhesive organ by means of which they can cling. When ready to become pupæ, the tip of the body is secured to the leaf, and after a time the skin is moulted and pushed down in a wrinkled blackish mass next the leaf, leaving the yellow and black pupa projecting. An alcoholic example of the pupa measures 0.26 inch in length. The wing pads extend downward close against the sides. The legs are held close against the breast.

Both larvæ and adults feed on the foliage, and can be destroyed by the use of sprays of Paris green, or of arsenate of lead. One pound of the former in 100 gallons of water is a good proportion, with enough freshly slaked lime added to make the whole milky in color. Of the arsenate of lead three pounds in 100 gallons may be used. The insects are little disturbed by birds owing probably to a powerful secretion, that can be recognized years after collecting, in alcoholic specimens.

The Willow Flea-Beetle.—A small oval, leaping, metallic green, blue, or bronzy, beetle, with pale brown antennæ and legs is common in early spring on willows and sometimes poplars and other trees, which it injures by gnawing round holes in the leaves. At times it becomes common enough to do severe injury, but generally its work on foliage is passed by unnoticed because of its insignificant character. The life-history of the insect is imperfectly known, beyond the fact that the adult lives through the winter. A specimen before me measures just 0.1 inch in length.

The Herald.—A green worm, rather common in late summer and fall among the leaves of willow trees in Kentucky, and while it never attracts general attention because of its injuries, frequently does enough to demonstrate its capacity in this direction should it at any time become sufficiently common. It produces a moth that is not uncommon at sirupy baits placed on the trunks of trees to attract night flying insects, and becomes especially common during the month of July. More than one brood is reared each season. The moths hibernate and are abroad in May, a brood of larvæ being ready for pupation by the last of the month, and yielding fresh moths by the middle of June. Larvæ have been taken also in October during which month adults commonly come out in numbers and conceal themselves for the winter.

A larva taken from willow October 1, 1898, was green, with a narrow black line along the upper part of the side, a reddish brown neck plate, and two ink-like blotches one on each side of the second and third body divisions. This larva began spinning a loose web for pupation October 3, and on October 4 had become a black pupa about 0.80 inch long and 0.24 inch in diameter. The surface is opaque and the abdomen tipped with several curved hooklets for clinging to the silken web.

This is the only moth known to me that habitually enters caves. This it does for hibernation, never, however, penetrating much beyond the penetration of light and being commonly found within the first twenty feet. Individuals have sometimes been found in the caves as early as the 12th of September, when larvæ were still present on the trees. They are found in the caves thereafter until spring, my latest date of capture being March 28. The situation chosen by these hibernating individuals is quite in keeping with the oddness of the moth. As far as observed they invariably cling to the walls overhead, where they are safe from pursuit by mice and other predatory cave inhabitants. On one occasion the bodies of individuals were found studded with droplets of moisture.

The Herald is a fine, though odd-looking moth. The wings expand about 1.6 inch, the front margin of the front wings being nearly straight except at the extreme tip where it is rather abruptly bent. The outer margin is strongly angled and is toothed both before and behind the angle. The hind wings are of the ordinary shape. Color of the front wings, drab, with a dash of ferruginous extending out from the base upon the disc of the wing. A pale zig-zag line extends across the outer part of the wing nearly parallel with the toothed and angled outer margin. Within this is a pair of sinuous white lines extending across from the front to the hind margins. Still another white line crosses the wing between this pair and the base of the wing. Besides these lines, each wing is marked with a distinct point of white on the disc, and with another at the base. The hind wings are dull gray above, with a curved dusky line crossing the disc. Beneath, the front wings are dotted along the front margin with dusky lines, and show traces of the lines of the upper surface. The hind wing is dotted with black, is crossed by a median dusky line, upon and outside of which is a large blackish smudge. The thorax is ferruginous, the abdomen drab. The legs are flecked with white, the tarsi of the middle and hind pairs being largely white. The moth is one of a few that appear to be indigenous both in America and in Europe.

The Willow Slug.—A black, slimy worm frequently appears on willows in Kentucky, and occasionally is found on poplar, both of which may be pretty completely denuded of foliage by it when it becomes extremely common. It is to be recognized among the willow and poplar frequenting insects by its dark color, and a row of eleven bright yellow spots along each side of the body. The hind part of the body is kept bent in a fashion peculiar to certain members of the saw-fly family to which this insect belongs. It is provided with six pairs of blue fleshy legs and a seventh pair of smaller ones is situated at the hind end of its body. The three well developed pairs of jointed legs are uniformly dark in color like the head and body. When first hatched it is pale in color, but assumes the characteristic dark hue on moulting its skin. When fully grown it measures 0.72 to 0.80 inch in length. Several broods appear each season.

The fly which lays the eggs from which this slug hatches appears about willows at Lexington very early in spring, and the slugs may be seen in large numbers on shrubby willows about the city reservoir in April and May. The very small greenish eggs are inserted by the female fly in slits which she makes with her ovipositor in the under side of the leaves. These cause the upper surface of the leaves to become roughened with little mounds, each indicating the position of an egg. The fly has four rather large thin membranous wings, hyaline, but slightly smoky tinted, the veins blackish. At the front margin at about the beginning of the outer third of the front wing, is an elongate blackish region known as the stigma. Specimens in the collection measure about 0.28 inch in length of body, are blackish in general hue, marked above on the segments with yellow, the body beneath largely yellow or green.

The insect is a near relative of the rose slug of our gardens but fortunately for our willows is not so generally distributed. Like the rose slug it may be destroyed by spraying infested plants with powdered white hellebore in water, or by the use in the same way of Paris green and freshly slaked lime.

Spraying with arsenate of lead, used at the rate of 5 pounds to 50 gallons of water, as soon as the young leaves are well developed is the most satisfactory remedy for combating this pest. If the application be made at that time, many of the adult beetles will be destroyed and egg-laying prevented. The banding process undoubtedly does considerable good, but the labor involved in watching the bands renders the cost out of proportion to the good accomplished.

The Locust Leaf Miner.—In many sections the locusts suffer so severely as to cause the browning and shedding of the leaves, large areas appearing as if scorched by fire. The adult is a flattened beetle about ¼ inch in length. The general color is red, broken by a medial line, with head, appendages and under surface black. The wings are deeply dotted with fine punctures.

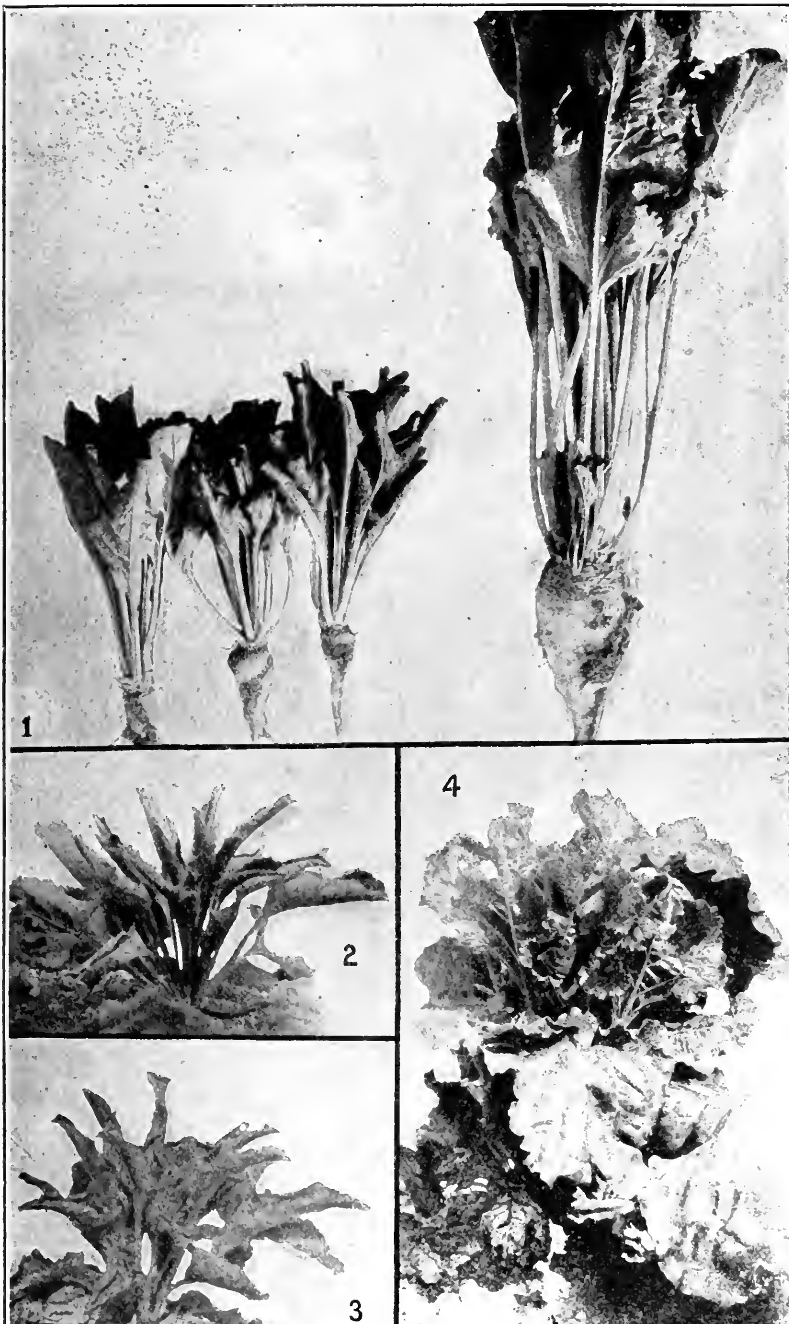
The winter is passed in the adult stage under trash in the vicinity of the feeding ground. In the spring the beetles emerge soon after the leaves of the locust are well grown. Eggs are deposited upon the surface of the leaves, and the young larva makes its way out through the under side of the eggshell into the tissue of the leaf, feeding until grown and pupating between the two layers of epidermis. The adults feed upon the leaves and may be found in the groves throughout the summer. The most satisfactory method of combating the pest is spraying thoroughly with arsenicals as soon as the locust leaves are out, that the beetles may be killed before egg laying is accomplished. This of course is impracticable for forest plantings.

The Locust Borer.—So destructive is the work of this insect upon locust trees that in some places the growing of a perfect tree is an impossibility. The adult belongs to that class of insects known as the long-horned borers. It is a black beetle, brilliantly marked with yellow lines; the long antennae and the legs are dull yellow and the length varies from 1½ to 1¾ inches. At the time the golden rod blossoms the adults appear and egg-laying commences. The female hurries about over the trunk of the tree, and when a crevice is found which suits her fancy she deposits a single white egg, then continues her search for another place.

The newly hatched larva bores through the outer layer of bark and rests in the white layer next the wood through the winter. With the advent of spring feeding is resumed, and the larva eats its way well into the body of the tree. If the tree is small the trunk may be almost severed and a slight wind may blow it over. The full grown larva is a creamy, club-shaped, footless grub, about ¾ inch in length.

The pupal stage is passed within the burrow, the adult emerging at the time previously stated. There remains to be found a practicable, effective, combative measure for this pest. Spraying the trunks of the trees with a repellant just previous to the time the females deposit their eggs is of some value, though not wholly effective. Whale oil soap and white-wash were applied to adjoining rows of trees in the Station planting, resulting in a slightly lessened injury during the season following. Injecting carbon bisulphide into the tunnels, by the use of an engineer's oil can, previous to the appearance of the adults and closing the tunnels with grafting wax was also partially successful in controlling the pest.

The Locust Twig Borer.—The presence of this insect in yellow locust groves is quite easily detected by its work upon the twigs of the tree. The smaller twigs become swollen and after a time white, sawdust-like material commences to drop from an opening in the enlarged section. The injury is the work of a lepidopterous larva, which upon the completion of growth, drops to the ground and pupates among the dried leaves. In this position the winter is passed. Although not exceptionally injurious it harms the tree to a certain extent. It is a question, however, whether combative measures are worth while. Should action be considered necessary, the affected twigs may be cut and burned while the larvæ are still pres-



WORK OF EUTETTIX ON SUGAR BEETS. DEPT. OF AGR.

ent in them, or the leaves containing the hibernating pupæ may be collected and destroyed during the winter.

The Sugar Maple Borer.—The adult or perfect insect of this maple borer is a large and handsome beetle, of the following characteristics: It is about an inch long, with a rounded body and rather long feelers or antennæ. The head is yellow with the antennæ and the eyes reddish-black; the thorax is black, with two transverse yellow spots on each side; the wing covers for about two-thirds of their length are black; the remaining third is yellow, and they are ornamented with bands and spots arranged in the following manner: A yellow spot on each shoulder, a broad, yellow, curved band or arch, of the yellow scutella, forms the keystone on the base of the wing-covers; behind this is a zig-zag yellow band, forming the letter W, across the middle another yellow band arching backwards, and on the yellow tip a black, curved band and spot; the legs are yellow; and the under side of the body is reddish-yellow, variegated with brown.

These beetles come forth from their burrows in the tree during July and August. During the latter month they lay eggs in the bark of sugar maples, selecting almost any part of the trunk for this purpose. In a short time—perhaps a week—these eggs hatch into small larvæ or grubs that burrow obliquely upward through the bark; their progress is slow, and more or less frass or castings are thrown out of the outer hole as they proceed. On this account the location of the little borers can generally be determined by looking the trees over carefully. The larvæ do not get beyond the bark the first autumn, and remain in their shallow burrows until the following spring. Then they burrow deeper into the solid wood of the tree, which thereafter they mine in all directions, the burrows growing larger as the insect increases in size. Finally the grub becomes full grown in this larval stage; it is now a large, white, legless creature, with the body composed of many distinct rings or segments. It makes a cell near the outer part of the tree in which it changes to the pupa or chrysalis state; and finally again changes into an adult beetle, which comes forth in July and August to continue the propagation of the species. This insect appears to confine its injuries to the sugar maple apparently, seldom, if ever, attacking the red maple.

As already indicated, the entrance of these borers is generally shown by the brownish, saw-dust like castings thrown out of the hole, and the larvæ remain in the shallow bark from September until the following spring. Consequently they can easily be cut out with a sharp knife, during autumn, winter, or spring, with little or no injury to the tree. This appears to be the most practical method of destroying them. Of course the beetles and older larvæ should be killed when found, and maple trees so seriously injured by this insect or from other causes as to show evident signs of dying should be cut down and converted into firewood—the wood to be burned before summer so that the larvæ present shall not mature—rather than be left standing to serve as breeding grounds for the pests.—(Bul. 33, N. H. E. S.)

Bronze Birch Borer.—The presence of this insect in birch trees is not easily determined until it has been at work for a year or more. The first intimation one usually has of its presence is the dying of some of the top branches of the tree. The whole tree often succumbs in another year or two. Rarely the trees might begin to die at the top from a condition known as stag head caused by lack of moisture and food materials. A careful examination should readily locate the borer if it is the culprit. Some have tried to save a tree by pruning out the dead branches or top, but without avail for by that time the whole tree usually is infested.

Sometimes one can determine in autumn whether a tree is infested by this insect, even before any branches have been killed. Characteristic reddish or rusty brown spots or discolorations often occur on the white bark of the trunk and larger branches at the point where the insect is preparing to hibernate and transform in the wood beneath. Usually the insect can be easily located by cutting through the bark and into the wood beneath these rather conspicuous spots. Another peculiarity which characterizes the work of the insect is the ridge which often develops in the bark over the burrow on the branches. Thus, while the insect works in rather an obscure manner, it indicates its presence in the above described characteristic and sometimes conspicuous ways. Unfortunately, however, it is usually then too late to save the tree, but much can be done to prevent further infestation of other trees.

This destroyer of white birches is a small, slender, olive-bronze colored beetle nearly half an inch in length (7.5-11.5 m m.). Its general color and the fact that it works mostly in birch trees suggested the good popular name of Bronze Birch Borer for the insect. However, it is not in this adult or beetle stage that the insect is destructive. It is injurious only during its life as a larva or grub when it is a borer.—(Bul. 234, Cornell Agr. Exp. Sta.)

The borer is a slender, flattened, footless, creamy white grub about three-fourths of an inch long when fully grown. Its small head with dark brown mouth-parts is retracted into the wide, flattened first thoracic segment giving it a flat-headed appearance. The other segments of the body are not so wide, the second and third thoracic being the narrowest. The caudal end of the body ends in two brown, horny, forceps-like processes with bidentate inner margins. It is this slender creature which is responsible for the killing of the trees. It may be found in autumn by cutting into the trees beneath the rusty-colored spots occurring on the bark. These grubs make tortuous or zigzag burrows in the sapwood around and across the trunk and branches of infested trees.

This borer attacks white birches of all sizes from nursery trees to stately monarchs more than a quarter of a century old. All parts of the tree, from branches a quarter of an inch in diameter to the main trunk, may be infested. The top branches are always first attacked and killed, then the infestation spreads into the other branches and trunk.

The tiny borer, hatching from an egg laid by the adult or beetle on the bark, begins a narrow mine or burrow through the bark. The burrow is extended in a tortuous or zigzag direction along the branch, getting wider as the borer grows, and running mostly in the sap-wood just beneath the bark, but sometimes going for a short distance deeper into the wood, even to the center of the branch.

There is no known way of preventing this bronze birch borer from attacking white birches, and the only practicable and effective method yet found for checking its ravages is to promptly cut and burn the infested trees in autumn, in winter, or before May 1st. There is no possibility of saving a tree when the top branches are dead. Cut and burn such trees at once and thus prevent the spread of the insect.—(Bul. 234, Cornell Agr. Exp. Sta.)

Wood Leopard Moth or Imported Elm Borer.—This is an insect that was accidentally imported over fifteen years ago from some European country and made its start at Hoboken. Practically all kinds of shade trees and many shrubs are attacked by the larva, which is both a borer and a true caterpillar. The parent moth is quite large, the males measuring an inch and a half and the females two and a half inches between the tips of the fore wings. These wings are white with numerous black spots and the body is black spotted in its anterior portion. The head in the male has a pair of densely feathered antennæ or feelers, and the abdomen extends back an inch and a half or more. Altogether the creature is readily recognizable and is found, during the season in which it flies, around electric lights in the cities where it occurs. The period of flight begins during the last days of May and extends through June, July and into August. It is during the latter days of June and in early July that the insects are most abundant and the males are always most active around the lights. The females are heavily built and, when the eggs are developing, rarely move far from the trees out of which they were born and upon which they afterward oviposit. The eggs are small, salmon-pink in color, and may be laid singly or in masses, a single adult depositing between five hundred and one thousand or even more. They are usually placed in a bark crevice or other sheltered situation and generally on one of the smaller branches. The little caterpillar, when it hatches, makes its way to the crotch of a small branch, or to one of the nodes or buds and at once bores into the wood tissue. It works downward, toward the base, and grows very rapidly. When it is tired of its quarters, or when they become too narrow, the insect works out; sometimes directly, sometimes by cutting all around on the inside so that the twigs break off. Then it makes its way further down, selects a larger branch and again begins feeding. Each individual seems to be a law unto itself as to the manner in which it feeds; it may bore a straight channel through the center of the branch, it may eat out a large cavity on one side, or it may deliberately work around and kill it. By the end of the first season the larva is half-grown and has usually made its way to one of the large branches, leaving behind it one or two that will be almost certainly broken by the winter winds.

During the second summer growth is rapid and the larvæ attain a length of two inches or more. On smaller trees they sometimes get into the trunk itself and may completely girdle it; or they may remain in the branches, or, in fact, work in almost any conceivable way, changing their location two or three times during the summer. At the end of this growing season they have reached their full size and, early in the spring following, work close to the surface and form pupæ, which, when the adults are ready to develop, wriggle their way out so that fully half projects beyond the bark when the moths emerge. The moths do not feed. The caterpillars do not feed upon the surface except for a short time, when they change their quarters and start at a new place. There is no chance of reaching the moths through poisonous applications and practically no chance of reaching the larvæ by means of insecticides.

Thus far the insect has been confined to the cities, and while occasionally in the outskirts specimens are found in trees, it is the exception rather than the rule and practically no injury is done in orchards or to the trees of smaller towns and villages. The larger the city the greater the injury, and the reason for that seems to be that in such places no birds, except English sparrows, are able to maintain themselves. Wherever this sparrow is completely in possession the insect is no longer to be feared.

Active measures are possible in one direction only. Every badly infested tree should be cut down and burnt, as its death is a mere matter of time at the best. Trees infested toward the tips only should be cut back in winter and the cuttings should be burnt. The openings to the burrows made by the larvæ are easily seen by the trained eye, especially during early summer, when the larva forces great strings of partly digested wood through the opening by which it entered. Where these burrows are in the trunks of valuable trees or shrubs, or in branches that cannot be easily spared, a few drops of bisulphide of carbon may be injected by means of an oil-can or a small syringe, and the opening closed with a lump of putty. The vapor of the bisulphide will penetrate the full length of the tunnel and kill the larva, wherever it may be, without injury to the tree. Most of this work can be done during the winter. During the summer the trees should be kept under constant supervision, and wherever signs of borers are noticed the infested wood should be cut out, or the borer should be destroyed by means of the bisulphide of carbon.

There are undoubtedly natural enemies other than birds that tend to keep this borer in check. If the work of these natural enemies is supplemented by systematic work on the part of those in charge of the trees, a great lessening of injury will result. If in the public parks and squares in the cities other birds than sparrows could be introduced and protected, the work would be much simplified.

The Maple Tree Sesiid.—This is another caterpillar borer, found in soft maples more generally. It makes round holes, not over one-eighth of an inch in diameter, in the solid wood, and the caterpillar is white, or nearly so, with short, stiff hair on the surface. It comes to maturity in spring, and some time during the latter part of May or June forms its pupa near the outer surface of the trunk. When ready to change to the adult stage, the pupa wriggles out for about half its length, just as the pupa of the leopard moth does, and, usually very early in the morning, the moth emerges. This is rather a handsome little creature, yellow with red trimmings and bandings, the wings thin and transparent. It is one of the clear wings and looks more like a wasp than a moth. Sometimes maples are infested by a large number of these insects, but experience indicates that little real harm is done to the trees, provided water does not get into the holes to cause decay. The borings are in the heart-wood only, and as the heart-wood has little to do with the actual nourishment of the tree, there is no immediate weakening. Where the insects are observed in numbers it will pay to whitewash the trunks several times during the season. This will be effective—first, by repelling the moths that would otherwise oviposit on the trunks; and, second, it will cover over or partly fill the small holes that have been made by the insects. A tree once infested will, under ordinary circumstances, remain infested, and there seems to be an individual attraction that does not extend to even neighboring trees of the same species.—(Bul. 181, N. J. E. S.)

INSECTS CAUSE THE DEATH OF TREES.

It has been conclusively demonstrated that certain species of insects are the direct or primary cause of the death of forest trees of all ages, and that from time to time they multiply to such an alarming extent that their depredations assume the character of a destructive invasion, which results in the death of a large percentage of the best timber over thousands of square miles.

There are many species of barkbeetles which prefer to attack matured and healthy trees, and there are many examples of whole forests of century-old trees having perished from the girdling effect of the mines of the beetles, which are extended in all directions through the inner living bark on the main trunks of the trees. Indeed, we find among these bark-boring beetles the most destructive insect enemies of North American forests. Some notable examples of the depredations of these barkbeetles are given below.

The Southern Pine Beetle.—In 1890-1892 a destructive invasion of the southern pine beetle extended from the western border of West Virginia through Maryland and Virginia into the District of Columbia, northward into southern Pennsylvania, and southward into North Carolina. In this area, aggregating over 75,000 square miles, a very large percentage of the mature and small trees of the various species of pine and spruce was killed by this beetle. In many places in West Virginia and Virginia nearly all the pine trees of all sizes on thousands of acres were killed, while shade and ornamental trees within the same area suffered the same as those in the forest. Since 1902 this barkbeetle has been more or less active in the Southern States from Virginia to Texas, and in some localities and during certain years it has killed a large amount of timber. Records of extensive destruction of timber in the Southern States are found dating back to the early part of the nineteenth century. This species may be considered one of the most dangerous insect enemies of southeastern conifers and, therefore, a constant menace to the pine forests of the Southern States.

The Eastern Spruce Beetle.—During the period between 1818 and 1900 there were several outbreaks of the eastern spruce beetle in the spruce forests of New York, New England, and southeastern Canada. This species caused the death of a very large percentage of the mature spruce over an area of thousands of square miles. In the aggregate many billions of feet of the best timber were destroyed. The larger areas of this dead timber furnished fuel for devastating forest fires, with the result that in most cases there was a total loss.

The Engelmann Spruce Beetle.—Another barkbeetle, similar in habits to the Eastern spruce beetle, has from time to time during the past fifty years caused widespread devastations in the Rocky Mountains region to forests of Engelmann spruce, in some sections killing from 75 to 90 per cent of the timber of merchantable size.

The Black Hills Beetle.—One of the most striking examples of the destructive powers of an insect enemy of forest trees is found in the Black Hills National Forest of South Dakota, where during the past ten years a large percentage of the merchantable timber of the entire forest has been killed by the Black Hills beetle. It is estimated that more than a billion feet of timber have been destroyed in this forest as the direct result of the work of this beetle. This destructive enemy of the western pine is distributed throughout the forests of the middle and southern Rocky Mountains region, where, within recent years, it has been found that in areas of greater or less extent from 10 to 80 per cent of the trees have been killed by it.

The Mountain Pine Beetle and the Western Pine Beetle.—The sugar pine, silver pine, western yellow pine, and lodgepole pine of the region north of Colorado and Utah, westward to the Cascades, and southward through the Sierra Nevadas are attacked by the mountain pine beetle and the western pine beetle, and, as a direct consequence, billions of feet of the timber have died. In one locality in northeastern Oregon it is estimated that 90 to 95 per cent of the timber in a dense stand of lodgepole pine covering an area of 100,000 acres has been killed within the past three years by the mountain pine beetle. Throughout the sugar-pine districts of Oregon and California, as the result of attacks by this same destructive barkbeetle, a considerable percentage of the largest and best trees is dead.

The Douglas Fir Beetle.—The Douglas fir throughout the region of the Rocky Mountains from southern New Mexico to British Columbia has suffered severely from the ravages of the Douglas fir beetle, with the result that a large percentage of dead timber is found, much of which will be a total loss. Three other species of beetles, having destructive habits similar to those above mentioned, depredate on the pines of New Mexico and Arizona, and still another has contributed greatly to the destruction of the larch throughout the northeastern United States and southeastern Canada.

The Hickory Barkbeetle.—Within the past ten years the hickory barkbeetle has caused the destruction of an enormous amount of hickory timber throughout the northern tier of States from Wisconsin to Vermont and southward through the eastern Atlantic States and into the Southern States as far as central Georgia.

The Larch Worm.—There are also many examples of widespread depredations chargeable to insects which defoliate the trees, thus contributing to their death. Notable among these are the depredations by the larch worm, which, during several extensive outbreaks since 1880, has killed from 50 to 100 per cent of the mature larch over vast areas in the northeastern United States and southeastern Canada. It is evident that the amount of merchantable-sized timber that has died as the result of defoliation by this insect will aggregate many millions of feet.

INSECT INJURIES TO THE WOOD OF LIVING TREES.

It has been determined that insects of a certain class attack the wood and bark of living timber and that, while they do not contribute materially to the death of the trees or give much external evidence of their presence, they produce wounds in the bark and wormhole and pinhole defects in the wood which result in a depreciation in commercial value amounting to from 5 to 50 per cent. These defects in the wood are not detected until after the trees have been felled and the logs transported to the mill and converted into lumber. Thus to the actual damage to the lumber is added the expense of logging and manufacture of the defective, low-grade material, much of which must be discarded as worthless culls.

The Oak Timber Worm.—One of the most destructive of the class of depredators just mentioned is the oak timber worm. It enters the wood of the trunks of living trees through wounds in the bark and at the base of broken or dead branches and extends its pinhole burrows in all directions through the solid heartwood. The losses occasioned by this insect in the hardwood forests of the eastern United States are enormous and usually affect the wood of the finest examples of old trees.

The Chestnut Timber Worm.—The chestnut throughout its range is damaged in a like manner by the chestnut timber worm. Practically every tree of merchantable size is more or less affected, and a large percentage is so seriously damaged that the product is reduced to that of the lowest grade. It is estimated that the reduction in value of the average lumber product at any given time is not far from 30 per cent, thus involving extensive waste and an increased drain on the forest to supply the requirements for clear lumber. This insect also attacks the oaks, and especially the red oak, the older trees of which are often as seriously damaged as are the chestnut.

Carpenter Worms.—The oaks, especially the white oak and the red oak, are seriously damaged by carpenter worms. The holes made by these insects through the heartwood of the best part of the trunks are sometimes 1.5 inches in diameter one way by 0.75 inch the other, thus causing serious damage to the wood. These, with other large wood-boring beetle larvæ, sometimes infest the top part of the trunk and the larger branches of oak trees, where their continued work results first in the dead and so-called staghorn top and subsequently in broken, decayed and worthless trunks.

Ambrosia Beetles.—One of the commonest defects in white oak, rock oak, beech, whitewood or yellow poplar, elm, etc., is that known to the lumber trade as grease spots, patch worm, and black holes. This defect is caused by one of the timber beetles or ambrosia beetles, which makes successive attacks in the living healthy sapwood from the time the trees are 20 or 30 years old until they reach the maximum age. Thus the black-hole and stained-wood defect is scattered all through the wood of the best part of the trunks of the trees. The average reduction in value of otherwise best-grade lumber amounts, in many localities, to from 25 to 75 per cent. The defect is commonly found in oak and elm furniture and in interior hardwood finish in dwellings and other buildings.

The Locust Borer.—The locust, as is well known, suffers to such an extent from the ravages of the locust borer that in many localities the trees are rendered worthless for commercial purposes or they are reduced in value below the point of profitable growth as a forest tree, otherwise this would be one of the most profitable trees in the natural forest or artificial plantation and would contribute greatly to an increased timber supply.

Turpentine Beetles and Turpentine Borers.—While the softwood trees, or conifers, suffer far less than the hardwoods from the class of enemies which cause defects in the living timber there are a few notable examples of serious damage. There is a common trouble affecting the various species of pine throughout the country known as basal wounds or basal fire wounds. It has been found that a large percentage of this injury to the pine in the States north and west of the Gulf States and in the Middle and South Atlantic States is caused by the red turpentine beetle and in the Southern States by the black turpentine beetle. These beetles attack the healthy living bark at and toward the base of the trunks of medium to large trees and kill areas varying in size from 1 to 10 square feet. These dead areas are subsequently burned off by surface fires and are then generally referred to as fire-wounds. The further damage to the exposed wood by successive fires, decay, and insects often results in a total loss of the best portion of the tree, or a reduction in value of the lower section of the trunk of from 10 to 50 per cent. These and similar wounds in the bark of trees, including those caused by lightning and by the uncovering and exposure of the wood in turpentining, offer favorable conditions for the attack of the turpentine borer, the work of which, together with that of two or three others with similar habits, is very extensive, and causes losses amounting to from 10 to 50 per cent of the value of the wood of the best part of the trees thus affected.

The White Pine Weevil.—The abnormal development of white pine trees as the result of successive attacks on the terminals of the saplings and young trees by the white pine weevil is an element of loss of considerable importance, especially in mixed stands and in open pure stands of this timber. The value of such trees is reduced from 20 to 50 per cent below those of normal development, and there is an additional loss from the effect of their spreading branches or crowns in the suppression or crowding out of trees which would otherwise occupy the space thus usurped. There are many other examples of insects which damage the wood and bark of living trees, but those mentioned should be sufficient to demonstrate the importance of insects in this relation.

INSECT INJURIES TO THE WOOD OF DYING AND DEAD TREES.

Timber dying from insect attacks and other causes, including fire, disease, storms, etc., is attacked by certain wood-boring insects which extend their burrows through the sound sapwood and heartwood, and thus contribute to the rapid deterioration and decay of a commodity which otherwise would be available commercially during periods of from one to twenty years or more after the death of the trees, depending on the species of trees and on the character of the product desired. This loss often amounts to from 25 to 100 per cent during the period in which the dead timber would otherwise be almost as valuable as if living.

CONIFEROUS TREES.

Sawyers.—One of the most striking examples of the destruction or deterioration of the wood of dying and dead timber, familiar to all lumbermen, is the injury to fire-killed and storm-felled pine, fir, spruce, etc., caused by boring larvæ known as "sawyers." These borers hatch from eggs deposited by the adult beetles in the bark of the dying trees, and after feeding on the inner bark for a time they enter the solid wood and extend their large burrows deep into the heartwood. Fire-killed white pine is especially liable to this injury and is often so seriously damaged within three or four months during the warm season as to reduce the value of the timber 30 to 50 per cent. The shortleaf, loblolly, and longleaf pines of the Southern States are damaged to a somewhat less extent, but instances are known in which more than one billion feet of storm-felled timber within limited areas were reduced in value 25 to 35 per cent within three months after the storm. The fire-killed and insect-killed sugar pine, silver pine, and yellow pine of the western forests are also damaged in a similar manner and the value of the product greatly reduced within a few months after the trees die. The aggregate losses from this secondary source in the coniferous forests of the entire country contribute largely to the annual waste of millions of dollars' worth of forest products which otherwise might be utilized.

Ambrosia Beetles.—Wood-boring insects of another class, known as timber beetles or ambrosia beetles, cause pinhole defects, principally in the sapwood, although some of them extend their burrows into the heartwood. These insects make their attack in the early stage of the declining or dying of the tree, or before the sapwood has materially changed from the normal healthy condition, and often in such numbers as to perforate every square inch of wood. Thus the wood is not only rendered defective on account of the presence of pinholes, but the holes give entrance to a wood-staining fungus which causes a rapid discoloration and produces still further deterioration of the product.

The sapwood of trees dying from the attack of other insects or from fire, storm, or other causes is often reduced in value 50 per cent or more, and in some cases the value of the heartwood is reduced in a like manner from 5 to 10 per cent.

Pinhole Borers in Cypress.—An example of the destructive work of insects which attack dying and dead trees is found in the cypress in the Gulf States, where these trees are deadened by the lumbermen and left standing several months, or until the timber is sufficiently dry to be floated. Upon investigation it was found that trees deadened at certain seasons of the year were attacked by the ambrosia beetles or pinhole borers, and that in some cases millions of feet of timber had been reduced 10 to 25 per cent or more in value.

HARDWOOD TREES.

Roundheaded Borers, Timber Worms and Ambrosia Beetles.—The principal damage to dying and dead hardwood trees is caused by certain roundheaded wood-borers with habits similar to the sawyer, by the timber worms mentioned as damaging living timber, and by ambrosia beetles having habits similar to those that attack the sapwood and heartwood of conifers. All of the hardwoods suffer more or less, but the greatest damage is done to the wood of hickory, ash, oak, and chestnut, which are often reduced in value 10 to 25 per cent or more within the period in which it would otherwise remain sound and available for commercial purposes.

INSECT INJURIES TO FOREST PRODUCTS.

Damage is caused by various species of insects which are attracted by the varying conditions prevailing at different stages during the process of utilizing the forest resources, from the time the trees are felled until the logs are converted into the crude and finished product and until the latter reaches the final consumer, or even after it is placed in the finished article or structure. As a result, additional drains are made on the timber to meet the demand for the higher grades of lumber and for other supplies to replace those injured or destroyed. From the writer's personal investigations of this subject in different sections of the country it is evident that the damage to forest products of various kinds from this cause is far more extensive than is generally recognized. This loss differs from that resulting from insect damage to standing timber in that it represents more directly a loss of money invested in material and labor.

CRUDE PRODUCTS.

Roundheaded Borers, Timber Worms, and Ambrosia Beetles.—Round timber with the bark on, such as poles, posts, mine props, sawlogs, etc., is subject to serious damage by the same class of insects as those mentioned under injury to the wood of dying and dead trees. The damage is especially severe when material is handled in such a manner as to offer favorable conditions for attack, as when the logs are left in the woods on skidways or in mill yards for a month or more after they have been cut from the living trees. Under such conditions there is often a reduction in value of from 5 to 30 per cent or more, due to wormhole and pinhole defects caused by roundheaded and flatheaded wood-borers and timber beetles. Frequently the insects continue the work in the unseasoned and even dry lumber cut from logs which had been previously infested. They also continue to work in mine props after they have been placed in the mine, and in logs and other material used for the construction of cabins, rustic houses, and in round timbers generally.

The products from saplings, such as hickory hoop-poles and like material, are often seriously injured or rendered worthless by roundheaded and flatheaded borers and wood-boring beetles, sometimes resulting in a loss of from 50 to 100 per cent of the merchantable product. Stave and shingle bolts left in moist, shady places in the woods or in close piles during the summer months are often attacked by ambrosia beetles and timber beetles. The value of the product is often reduced, as a consequence, from 10 to 50 per cent or more.

Handle and wagon stock in the rough is especially liable to injury by ambrosia beetles and roundheaded borers. Hickory and ash bolts from which the bark is not removed are almost certain to be greatly damaged if the logs and bolts cut from living trees during the winter and spring are held over for a few weeks after the middle of March or first of April.

Pulpwood and cordwood for fuel and other purposes, cut during the winter and spring and left in the woods for a few weeks or months or in close piles after the beginning of the warm weather, are sometimes riddled with wormholes or converted into sawdust borings, causing a loss of from 10 to 100 per cent. One example reported from near Munising, Mich., represents a loss of $5,000 from injury to spruce and fir pulpwood cut in the winter and kept in piles over summer.

MANUFACTURED UNSEASONED PRODUCTS.

Ambrosia Beetles and Other Wood Borers.—Freshly sawed hardwood placed in close piles during warm, damp weather during the period from June to September is often seriously injured by ambrosia beetles. Heavy 2-inch to 3-inch stuff is also liable to attack by the same insects, even in loose piles. An example of this was found in some thousands of feet of mahogany lumber of the highest grade, which had been sawed from imported round logs and piled with lumber sticks between the tiers of plank. Native species of ambrosia beetles had entered the wood to such an extent as to have reduced the value 50 per cent or more within a few weeks. Oak, poplar, gum, and similar woods often suffer severely from this class of injury, causing losses varying from 5 to 50 per cent.

Lumber and square timbers of both soft and hard woods with the bark left on the edges are frequently damaged by flatheaded and roundheaded wood borers, which hatch from eggs deposited in the bark before or after the lumber is sawed. There are examples of losses from this character of injury amounting to from 20 to 50 per cent or more. Telegraph and telephone poles, posts, mine props, etc., are frequently injured before they are set in the ground, especially if the bark remains on them during a few weeks after the middle of March.

SEASONED PRODUCTS IN YARDS AND STOREHOUSES.

*Powder-Post Beetles.**—Hardwood lumber of all kinds, rough handles, wagon stock, etc., made partially or entirely of sapwood, are often reduced in value from 10 to 90 per cent by a class of insects known as powder-post beetles. The sapwood of hickory, ash, and oak is most liable to attack. The reported losses from this source during the past five or six years indicate that there has been an average reduction in values of from 5 to 10 per cent or more. Old hemlock and oak tanbark is often so badly damaged by various insects which infest dead and dry bark that in some tanyards as much as 50 to 75 per cent of the bark that is over three years old is destroyed. In one tannery in West Virginia it is estimated that more than $30,000 worth of hemlock bark was thus destroyed.

FINISHED PRODUCTS.

The greatest loss of finished hardwood products, such as handle, wagon, carriage, and machinery stock is caused by powder-post beetles. This is especially true of hickory and ash handles and like products in the large and small storehouses of the country, including the vast amount of material held in storage for the army and navy. When material of this kind is once attacked it is usually worthless for the purposes indicated, and therefore must be replaced with new material. In some cases losses have amounted to from 10 to 50 per cent, and it is estimated that the average losses have been as much as 10 per cent on nearly all sapwood material that has been in storage more than one year.

UTILIZED PRODUCTS.

Powder-Post Beetles, White Ants, and Other Wood-Boring Insects.—The finished woodwork in implements, machinery, wagons, furniture, and the inside finish in private and public buildings are often seriously damaged by powder-post beetles, thus requiring increased demands for new material.

Construction timbers and other woodwork in new and old buildings are often so seriously damaged by powder-post beetles, white ants, and other wood-boring insects that the affected material has to be removed and replaced by new, or the entire structure torn down and rebuilt. Construction timbers in bridges and like structures, railroad ties, telephone and telegraph poles, mine props, fence posts, etc., are sometimes seriously injured by wood-boring larvæ, termites, black ants, carpenter bees, and powder-post beetles, and sometimes reduced in efficiency from 10 to 100 per cent.

INSECTS AND THE FUTURE SUPPLIES OF TIMBER.

Insects not only reduce future supplies by killing the mature trees and destroying the wood of timber that is inaccessible for utili-

*See illustration on page 663.

zation, but through injuries inflicted upon trees during the flowering, fruiting, germinating, seedling, and sapling periods of early growth they prevent normal reproduction and development.

INTERRELATIONS OF FOREST INSECTS AND FOREST FIRES.

Losses from Forest Insects.—The writer estimates that for a ten-year period the average amount of timber in the forests of the entire country killed and reduced in value by insects would represent an average loss of $62,500,000 annually.

Insect-Killed Timber as Fuel for Fires.—It has often happened that after insects have killed the timber over extensive areas the standing and fallen dead trees furnished fuel for great forest fires which have not only destroyed or charred the dead timber but killed the living timber and reproduction and swept on into adjacent areas of healthy timber. Indeed, abundant evidence has been found during recent investigations to indicate that some of the vast denuded areas in the Rocky Mountains and other sections of the country are primarily due to widespread devastation by insects, and that subsequent fires destroyed the timber and prevented reproduction.

It is also evident that a considerable percentage of dead timber, and especially that found in coniferous forest regions, which has generally been believed to have been fire-killed is a result of primary attack by insects. This has been demonstrated in many cases by the pitch-marked galleries of the destructive barkbeetles on the surface of the wood of the old dead trees which had escaped subsequent fires.

INTERRELATION OF FOREST INSECTS AND FOREST FUNGI.

Decay Following Injury by Insects.—It is well known that the burrows in the bark and wood of living and dead trees and in the crude and finished products often contribute to the entrance of bark and wood decaying fungi. Deterioration and decay are thus far more rapid than would otherwise be possible.

SUMMARY OF INSECT DAMAGES.

The killing of trees by insects; the damage by them to the wood of living, dying, and dead timber; the destruction of insect-killed timber by subsequent forest fires; the damage to fire-killed timber by insects; and the damage from decay resulting from insect injuries to the wood, have all been more or less continuous for centuries and are still going on in the forest and woodland areas of this country.

While these depredations are not always evident or important in all forests or localities, yet almost every year, somewhere in the forests of the country, there are widespread depredations. In every forest and woodland there is an ever present but inconspicuous army of insects which require the bark, wood, foliage, and seeds of the various tree species for their breeding places or food. Thus, the accumulated but inconspicuous injuries wrought during the period required for the growth of a tree to commercial size go far toward reducing the average annual increment below the point of profitable investments.

The accumulated damage to crude, finished, and utilized products reduces the profits of the manufacturer, increases the price of the higher grades to the consumer, and results in an increased drain on the natural resources.

The total value of the forest products of the United States in 1907 is given as $1,280,000,000; the losses from insect depredations at 8% would represent an annual loss in a cash value of more than $100,000,000.

Reduction in Value of Finished and Commercial Products.—When we consider the aggregate loss to the manufacturers of the finished products, to the trade, and to the consumer from insect injuries to the wood, it is evident that it amounts to many millions of dollars in addition to the estimated loss of crude products, or at least 3 per cent of the mill value.

METHODS OF PREVENTION AND CONTROL.

The results of extensive investigations and of practical applications of the knowledge gained during recent years have demonstrated that some of the most destructive insect enemies of American forests and of the manufactured and utilized products can be controlled, and serious damage prevented, with little or no ultimate cost over that involved in forest management and business methods.

There are, of course, certain insects and certain injuries which, under present conditions and available information, can not be controlled or prevented, but it is very evident that if the information now available through the publications of the Department of Agriculture and through direct correspondence with its experts is properly utilized in the future it would result in the prevention of at least 30 per cent of the estimated annual waste of forest resources that has been caused by insects within recent years, and thus contribute greatly to the conservation of forest resources.

GENERAL PRINCIPLES OF CONTROL.

The ordinary spraying and similar methods employed in dealing with fruit and shade tree insects are, of course, not available for practical application in the case of forest trees. But there are other and less expensive methods of accomplishing the desired results.

In all efforts to control an outbreak or prevent excessive loss from forest insects it should be remembered that as a rule it is useless to attempt the complete extermination of a given insect enemy of a forest tree or forest product. Experience has demonstrated that it is only necessary to reduce and weaken its forces 75 per cent or more. It can not then continue an aggressive attack, but must occupy a defensive position against its own enemies until conditions resulting from avoidable negligence and mismanagement by the owners of the forests and manufacturers of forest products favor its again becoming destructive. Forest insects can thus be easily kept under control by good management.

The desired control or prevention of loss can often be brought about by the adoption or adjustment of those requisite details in forest management and in lumbering and manufacturing operations, storing, transportation, and utilization of the products which at the least expenditure will cause the necessary reduction of the injurious insects and establish unfavorable conditions for their future multiplication or continuance of destructive work.

It is, however, of the utmost importance that any adjustment or modification in management or business methods should be based on expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved and the essential features of the methods for their control. This should be supplemented by expert knowledge or advice on the principles of technical and applied forestry in the proper management, care, and utilization of the forest and its resources, and still further supplemented by practical knowledge and experience relating to local conditions and facilities favorable and unfavorable for success in practical applications according to the recommended method or policy of control.

As has been shown, the mature or merchantable timber is the most susceptible to injury or death from the ravages of insects. Therefore, considered from the standpoint of insect control and the prevention of one of the greatest items of loss, it is important that such matured timber should be utilized before it begins to deteriorate, or before it reaches the stage of unprofitable growth.

For the greatest success in dealing with forest insects, it must be recognized that there are certain features in the habits and seasonal history of each species which differ to a greater or less extent from those of all other species, even of the same genus; that there are certain features in the characteristics of the various species of trees which differ from those of all other species; and that as a rule it is the technical knowledge of these peculiar features or characteristics of the trees and their enemies which furnishes the clew to successful methods of control.

There are also many peculiar features in the prevailing conditions in different localities, some of them favorable, others unfavorable, for the practical application according to a given method, so that while certain general advice may apply in a broad sense and be available for utilization by the practical man, whether owner, manager, or forester, without further advice it is often necessary to diagnose a given case before specific expert advice can be given as to the exact cause and the most effective method or policy to be adopted, just as a physician must diagnose a case of illness or injury before prescribing the required treatment for his patient.

Therefore, in a consideration of the problem as to how far the waste of forest resources caused by insects can be prevented and how far the damaged timber can be utilized, we will attempt to give only general statements based on the results of our observations relating to some of the principal kinds of loss discussed in the first part of this paper, namely, by insects which (1) kill the trees, (2) cause injuries to the wood of living timber, (3) reduce future supplies, and (4) cause injuries to the manufactured products. In addition, we will consider the utilization of natural enemies of injurious insects, the utilization of damaged timber, and the present conditions and opportunities for success in the general control of forest insects.

CONTROL OF BARKBEETLES WHICH KILL TREES.

The barkbeetles which kill trees attack the bark on the trunk and destroy the life of the tree by extending their burrows or galleries in all directions through the inner living bark. The broods of young grubs or larvæ develop within the inner bark, on which they feed. Those of some species develop to the adult stage within the inner bark and are exposed when the bark is removed, while those of other species transform to the adults in the outer corky bark and the larvæ are not exposed when the bark is removed. Some species have two or more generations in a season or annually, while others have but one, and in a few species it requires two years for a single generation to develop.

The barkbeetles of the genus Dendroctonus represent the most destructive enemies of the principal coniferous tree species of American forests, and at the same time are among the easiest to control. The general requisites for success are embodied in the following rules:

(*a*) Give prompt attention to the first evidence of a destructive outbreak, as indicated by an abnormal percentage of yellow or red topped dying trees, and especially when such trees occur in groups of ten or more or cover large areas; (*b*) secure authentic determination of the particular species of insect responsible for the trouble; and (*c*) take prompt action toward its control according to specific expert advice, published or otherwise, on the best method for the destruction of the necessary 75 per cent or more of the insects in the infested trees. Some of the methods to be adopted to meet the requirements of various local conditions are as follows:

(1) Utilize the infested timber and burn the slabs during the period in which the broods of the destructive beetles are in the immature stages or before the developed broods emerge from the bark; or

(2) Fell the infested trees and remove the bark from the main trunk and burn the bark if necessary;* or

(3) Remove the infested bark from the standing timber and burn the bark when necessary;* or

(4) Immerse the unbarked logs in ponds, lakes, or streams, where the bark will remain soaked long enough to kill the insects; or

(5) Remove the unbarked logs or products to a locality where there are no trees liable to attack within a radius of 20 miles or more.

MAINTAINING CONTROL OF BARKBEETLES.

Future trouble of a serious nature from barkbeetles which kill trees can be prevented within a given forest or area of greater or less extent if an insect-control policy is adopted in connection with, or independent of, a fire-control policy by which groups of dying trees will receive similar prompt attention as that required for the prevention or control of forest fires.

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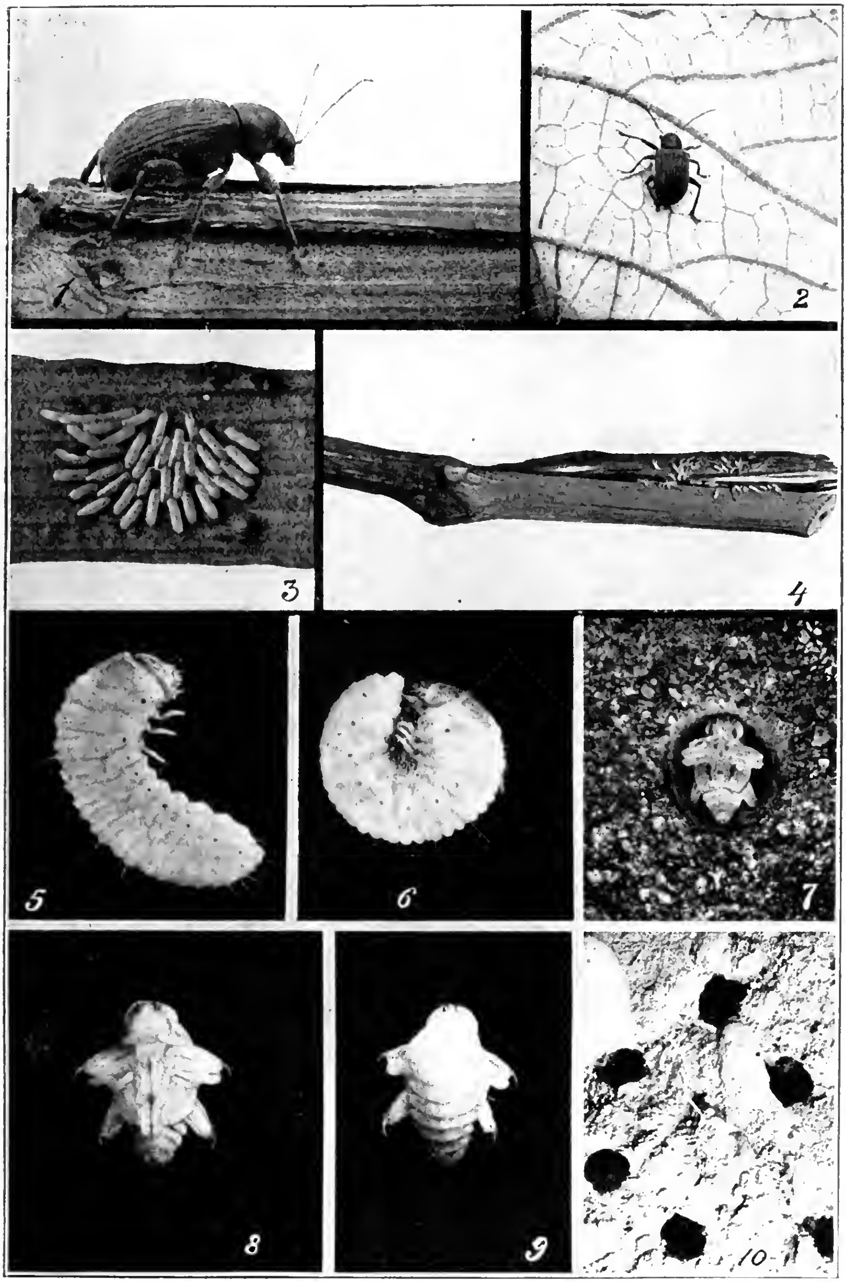
*If the broods develop to adults in the outer bark, it must be burned; if they develop in the inner bark and are exposed when the bark is removed, burning is not necessary. As a rule the burning of the tops to destroy the insects is not necessary.



Grape Root-Worm (Fidia Viticida) in Various Stages. Dept. of Agr.

(See page 77.)

In State and National Forests.—In all forest reserves in which there is an organized force of rangers and fire wardens or patrols each officer should be furnished with instructions for the location of beetle-infested trees, and with equipment and directions for taking the necessary action whenever the conditions demand or warrant it.

In Private Forests.—Private forests should receive the same attention as public forests, but this is often far more difficult on account of intervening forests, where the owners either can not or will not give the matter the required attention. While it may be advisable to have some laws to govern the treatment of timber infested with a dangerous pest, when the owner refuses to take any action such a law should apply only to the more extreme cases or as a last resort on authoritative advice. It is probable that in most cases legislation will not be necessary, and more ultimate good will result without than with strict laws, especially when it can be made clear to the owner that his personal interests demand that he take the proper action and that, when necessary, his neighbors will render assistance, as is done in the case of a forest fire.

Inaccessible Areas.—There are yet large inaccessible areas in the East and West where it is not practicable or possible at present to control the depredations by these beetles and which must therefore be left to the same natural adjustment that has been going on in all forests from their beginning. While under such natural control much of the older matured timber will be lost and will usually be replaced by young growth, either of the same species of trees or of a different species, so that under normal conditions the forest will be perpetuated; but under exceptional conditions and combinations of detrimental influences, such as secondary insect enemies, fire, drought, etc., extensive areas may be completely denuded, never to be reforested under natural conditions. Therefore it will evidently not be very long before it will pay to adopt insect-control policies even in the areas that are inaccessible for profitable lumbering.

CONTROL OF INSECTS WHICH INJURE LIVING TIMBER.

The class of insects which causes defects in the wood of living timber can be controlled to a greater or less extent, depending upon local conditions, and a large percentage of the losses prevented through the adoption of certain requisite details in forest management. Of these the following are especially important:

(1) The utilization of all of the defective and infested timber that will pay expenses for manufacture into merchantable products, such as lumber, cordwood, etc.

(2) The burning of infested timber and waste material not available for use, including dead standing and fallen timber, to remove the breeding places of insects like the oak timber worm and the chestnut timber worm, which go from the dead to the living timber.

(3) The prevention of wounds of any kind in the bark of living trees.

(4) The prevention of future losses by the practice of improved forestry methods which will eliminate favorable conditions

for injury and contribute to a perpetual supply of vigorous, healthy timber to be utilized before it passes the stage of profitable increment.

PREVENTION OF INJURY TO DYING AND DEAD TREES.

A large percentage of the injury to the wood of insect, fire, and lightning killed trees and those killed or dying from injuries by storms, disease, etc., can be prevented as follows:

(1) By the prompt utilization of such timber within a few weeks or months after it is dead or found to be past recovery.

(2) By removing the bark from the merchantable portions of the trunks within a few weeks after the trees are dead (the work to be done either before or after the trees are felled).

(3) By felling the trees and placing the unbarked logs in water.

(4) By the adoption of a system of forest management which will provide for the prompt utilization of all trees which die from any cause.

PREVENTION OF LOSS FROM INSECT INJURIES TO NATURAL AND ARTIFICIAL REPRODUCTION.

The successful control of the insects which destroy or prevent the normal development of natural reproduction is a far more difficult problem than that presented by other classes of insect injuries, but in this as in the others a great deal can be accomplished toward preventing the reduction of future supplies.

Much can be accomplished in nurseries and small plantations by the adoption of the ordinary methods of controlling farm and orchard insects, but in the natural forests reliance must be placed largely on systems of forest management which will bring about unfavorable conditions for the work of the more important enemies.

PREVENTION OF INSECT INJURIES TO FOREST PRODUCTS.

The problem of artificial control and prevention of insect injuries to forest products offers less difficulties perhaps than that relating to many other branches of the general subject of forest-insect control. In most cases the principle of prevention is the only one to be considered, since the damage is done soon after the insects enter the wood, and therefore it can not be repaired by destroying the enemy.

CRUDE PRODUCTS.

The proper degree of moisture found in the bark and wood of newly felled trees, saw logs, telegraph poles, posts, and like material, cut in the fall and winter and left on the ground or in close piles during a few weeks or months in the spring and summer, or during the period when the particular species of injurious insects are flying, are some of the conditions most favorable to attack. The period of danger varies with the kind of timber and the time of the year it is felled. Those felled in late fall and winter will generally remain attractive to ambrosia beetles and adults of round and flat headed borers during March, April, and May. Those felled during the period between April and September may be attacked in a few days after they are felled, but the period of danger from a given species of insects may not extend over more than a few weeks. Thus certain kinds of trees felled during certain seasons are never attacked, while if they are felled at other times and seasons the conditions for attack may be most favorable when the insects are active, and then the wood will be thickly infested and ruined. The presence of bark is absolutely necessary for successful infestation by most of the wood-boring grubs, because the eggs and young stages must occupy the inner and outer portions before the latter can enter the wood. Some ambrosia beetles and timber worms will, however, attack barked logs, especially those in close piles or otherwise shaded or protected from rapid drying. A large percentage of the injury to this class of products can be prevented, as follows:

(1) Provide for as little delay as possible between the felling of the tree and its manufacture into rough products. This is especially necessary with trees felled from April to September in the region north of the Gulf States and from March to November in the latter, while the late fall and winter cuttings should all be worked up by March or April.

(2) Do not leave the round timbers in the woods or on the skid-ways during the danger period, or, if this is unavoidable, take every precaution to facilitate the rapid drying of the inner bark by keeping the logs off the ground, in the sun, or in loose piles, or else, if possible, the opposite extreme should be adopted and the logs kept in water.

(3) Remove the bark within a few days after the trees are felled, from poles, posts, and other material which will not be injured by checking or season cracks.

(4) Take advantage of the proper months or seasons in which to fell or girdle different kinds of trees to avoid danger.

Damage to products cut from saplings and left with the bark on can be prevented by transporting the material from the woods soon after it is cut, so that it will not be left in piles or bundles in or near the forest during the season of insect activity. Damage may also be prevented by care not to leave the material stored in one place for several months.

Pinhole damage to stave and shingle bolts cut during a warm season can be prevented by removing the bark from the timber as soon as it is felled and by converting the bolts into the smallest practicable dimensions and piling them in such a manner as to facilitate rapid drying.

Damage to unseasoned handle and wagon stock in the rough can be prevented by taking special precautions to provide against the same favorable conditions for attack as mentioned in connection with round timbers. This is especially necessary with hickory and ash if cut during the winter and spring.

Damage to pulpwood and cordwood can be prevented to a great extent by placing the sticks of wood in triangular or crib piles immediately after they are cut from the trees, especially if the timber is cut during the danger period or must be held for a few months during the warm season. Peeling or splitting the wood, or both, before it is piled will also provide against damage from insects.

MANUFACTURED PRODUCTS.

Freshly sawed hardwood lumber placed in close piles during warm, damp weather in the period from July to September, inclusive, presents the most favorable conditions for injury by ambrosia beetles. In all cases it is the moist condition and retarded drying of the lumber which induces attack. Therefore any method which will provide for the rapid drying of the lumber before or after piling will tend to prevent loss. It is important, also, that heavy lumber should, as far as possible, be cut only in the winter and piled so that it will be well dried out before the middle of March.

The damage to lumber and square timber when the bark is left on the edges or sides can be prevented by removing the bark before or immediately after the lumber is sawed, or by sawing and piling the material during the winter, or if sawed at other times it should be piled so that rapid drying will be facilitated.

SEASONED PRODUCTS.

Unfinished Seasoned Products.—Injury by powder-post beetles to dry hardwood lumber and other material in stacks or storehouses can be prevented as follows:

(1) Have a general inspection of the material in the yards and storehouses at least once a year, preferably during November or February, for the purpose of (*a*) sorting out and destroying or otherwise disposing of any material that shows the slightest evidence of injury, as indicated by the presence of fine powdery boring dust, and (*b*) sorting out and destroying all old and useless sapwood material of any kind that will offer favorable breeding places for the insects.

(2) Prevent the introduction into the lumber yards or storehouses of any infested material, remembering that the insect may be thus distributed to or from all parts of the world.

(3) Adopt a system of classification of all dry or seasoned hardwood stock which will provide for (*a*) the separation of the pure, heartwood material from the pure and part sapwood material; (*b*) classification of all kinds of wood most liable to attack, such as hickory, ash, oak; (*c*) the successive utilization or sale of the older material (remembering that material one year old or over is far more liable to injury); (*d*) providing against the accumulation of refuse material in which the insects could breed; and (*e*) treating the best material with linseed oil or kerosene to prevent attack.

Finished Seasoned Products.—Damage to finished handles, oars, spokes, rims, hubs, wheels, and other unpainted wagon, carriage, machinery and implement stock in factories, wholesale and retail storehouses, and army and navy stores can be prevented by the adoption of the same general rules as those given under rough products. In addition, damage can be controlled and prevented in the following manner:

Sort out and (*a*) destroy all articles showing the slightest evidence of powder-post injury, or (*b*) treat with kerosene oil such infested and slightly injured articles as may be tested for required strength and found to be of sufficient value for retention, placing the same in quarantine for a sufficient time to determine whether the treatment is successful.

Damage by powder-post insects to many kinds of articles can be prevented and at the same time the material otherwise benefited by treating the sapwood with linseed oil or kerosene, either by immersing it in the oil or by applying the oil with a brush, the application to be made as soon as possible after the articles are finished from recently seasoned, uninjured stock.

TAN BARK.

Damage to hemlock and oak tan bark by the class of insects which in some cases has been so destructive to these products in the past can be easily prevented without cost, as follows:

(1) Utilize the bark within three years from the time it is taken from the trees.

(2) Prevent the accumulation in the yards and store-sheds of old bark and waste material in which the insects can breed.

These simple methods have been extensively adopted since their recommendation in correspondence and publications between about 1894 and 1904, and afford one of the most striking examples of the value of expert information on the peculiar habits of insects and of how millions of dollars can be saved without cost through a simple adjustment in methods of utilization.

UTILIZED PRODUCTS.

Damage and loss from insect injuries to timber and other woodwork in structures of various kinds, to telephone and telegraph poles, posts, railroad ties, mine props, etc., can be prevented to a large extent through the adoption of the proper methods of management or of treating the material with preservatives before and after it is utilized.

TIMBERS AND WOODWORK IN STRUCTURES.

Injuries to timbers and woodwork in dwellings, outbuildings, bridges, etc., by powder-post insects can be prevented as follows:

(1) Use nothing but heartwood for the concealed parts most liable to damage.

(2) If it is necessary to use all or part sapwood material, attack can be prevented by treating the sap portions with kerosene, coal tar, creosote, or linseed oil. Facilities for future treatment can be provided wherever the rough or finished woodwork is exposed, as in outbuildings, bridges, etc., if care is taken to expose the sapwood portions.

(3) If the untreated timbers and woodwork in old buildings show evidence of attack, the affected portions should be given a liberal application of kerosene.

Damage by white ants, or termites, can often be prevented in the following ways:

(1) By the use of nothing but sound wood for underpinning and foundation timbers and the removal of decaying timbers from old structures.

(2) By preventing moist conditions of the wood in any part of the structure and especially that in foundation timbers.

(3) By the treatment of timbers necessarily exposed to moist conditions with creosote, zinc chloride, corrosive sublimate, etc.

(4) If the timbers become infested, further progress of insect damage can be prevented by removing the badly damaged parts and soaking the remainder with kerosene, fumigating with bisulphid of carbon, and by removing any adjacent decaying or other wood in which the insects have been breeding or may breed, such as logs, stumps, etc.

Log Cabins and Rustic Work.—Damage by bark and wood boring insects to the unbarked logs and poles used in rustic cabins, summer houses, fences, etc., can be largely prevented by cutting the material in October and November and utilizing it at once, or by piling it off the ground or under cover in such a manner as to offer the best facilities for the rapid and thorough drying of the inner bark before the middle of March or the 1st of April following. If these necessary precautions are not taken, and there is evidence that insects are at work in the bark and wood, the damage can be checked by injecting bisulphid of carbon through natural or artificial openings in the affected bark, and immediately stopping these and other openings with putty or a similar substance.

Poles, Posts, Piles, Ties, Mine Props, and Similar Products.—Insect damage to poles, posts, and similar products can be prevented to a greater or less extent by the preservative treatments which have been tested and recommended by the Forest Service for the prevention of decay. These should be applied before the material is utilized for the purposes intended, or, if it be attacked after it has been utilized, further damage can be checked to a certain extent by the use of the same substances.

It is often of prime importance to prevent injury from wood-boring insects, for the reason that such injuries contribute to more rapid decay. Therefore anything that will prevent insect injury, either before or after utilization of such products, will contribute to the prevention of premature deterioration and decay.

The Browntail Moth. The Gypsy Moth. The Forest Tent Caterpillar And all other leaf injuring insects.	See Insects Affecting Shade Trees and Ornamentals.

—(Bul. 58, Part V, B. E. U. S. D. A.)

INSECTS OF FARM HOMES.

SOME HOUSEHOLD PESTS.

Not only the agriculturist and horticulturist has his plague of bugs—the housekeeper has troubles of a similar nature to contend with, and some of those are just as obstinate and difficult to manage as those in the field and orchard. Nothing escapes insect attack, from the carpet to the baby, and there is no kind of food product that is not liable to become infested.

Roaches.—Three species of roaches occur in houses—two of them commonly, one of them rarely, and usually confined to stores and warehouses, especially where flour or grain products are stored. Of these, the least common, as well as the largest, is the American roach, fully two inches in length and with well-developed wings in both sexes. They are light brown in color, the thorax or shield covering the head, with an obscure, yellowish border. It is this native species that seems to be confined to stores, mills and warehouses, and where it occurs neither of the other species are found.

The most common and most disgusting species is the oriental roach, a clumsy, black species, from an inch to one and a quarter inches in length, the male with wing cases that extend from half to three-fourths of the distance to the end of the abdomen, the female with only rudiments of wings.

The third and smallest species is the German roach, from one-half to three-quarters of an inch in length, light yellowish brown in color, with wing covers that reach to the end of the body, and with well-developed under wings, which are rarely, if ever, used in actual flight. This is quite generally known as the croton bug, and is perhaps the most common and widespread in cities and large towns. It is more frequently found on the upper floors of buildings than the oriental roach, and is quite usually found with it. Where one species only is found in a house, this small species is tolerably sure to be the one.

All these kinds resemble each other in general appearance, developments and habits. All of them are omnivorous, feeding upon any soft, moist food remnants, animal or vegetable, and gnawing starchy surfaces, ranging from newly-laundered shirt fronts to glazed paper or book-bindings. They will on occasion eat each other and are said to be fond of bed-bugs; but the two have been known to coexist in unpleasant numbers in the same house. In all cases the mouth is bent under so that the jaws work practically between the front legs, and therefore the insects must really straddle their food when eating. All of them are thin and flattened, with long spiny legs that extend well out at the sides, and with very long slender feelers. They are, therefore, capable of getting into very narrow openings, and live under and behind baseboards, in the cracks of the floors, behind wainscotings, around stoves and in the numerous cracks and crevices generally found in kitchen and pantry fittings and closets.

They are nocturnal in habit; the oriental roach or black beetle, most completely so, being rarely seen during the day even where it is very plentiful; the croton bug least so, making its appearance not uncommonly in broad daylight where at all numerous. All of them are nasty to handle, but the black beetles are the most disgusting to the senses of touch and smell.

There is only one brood during the season, and in cold weather the insects are dormant or at least inactive, except in very warm kitchens or bakeries. In the spring the females begin to develop an ootheca or egg case, which extends from the end of the abdomen in the form of a pod, containing a large number of eggs, placed side by side. This case is carried about until the eggs are ready to hatch;

it is then dropped in some sheltered corner or crevice and splits open along one side, where a seam exists, giving the young a chance to escape. The young are without trace of wings until late in fall, and grow very slowly. All the species run rapidly and even the heavy oriental gets over the ground at a surprising gait and climbs remarkably well.

In general, the insects favor warm and moist places, and they are, therefore, most abundant where such conditions occur. In the southern parts of the country they are much more abundant than further north, and even a little difference in average temperature makes a great difference in degree of infestation.

Roaches may be carried from place to place in many ways and find no difficulty in getting from one house to another in a row. In detached houses they are usually introduced from infested localities. I have seen specimens in a basket of laundry brought from the washerwoman, and in a box of groceries brought from the store. If such specimens are of both sexes, or if even one is a fertilized female, colonization is complete.

The actual damage done by these insects is not often very great; but they are not nice to have around, and often muss and spoil food products or give the utensils invaded by them an unpleasant odor which is not easily gotten rid of. The housekeeper, therefore, is usually anxious to clear them out.

Where matters have become very bad, or in stores or warehouses, fumigating with the hydro-cyanic acid gas, as later described, is the most effective and on the whole the simplest remedy. If the application is made in early spring or late fall, either before the egg cases have matured or after the young have all hatched, one fumigation will be sufficient. If it is made while the females are carrying fully matured egg pods, a second application a month later may be necessary. Sulphur is also useful and even pyrethrum may be employed to good advantage.

In dwellings where the infestation is limited or not serious, milder measures are available. In the first place, kill all roaches whenever they are seen; with putty, white lead or other substances fill up the cracks and crevices where the insects usually hide, so as to reduce their retreats as much as possible.

Places that cannot be reached in this way should be thoroughly syringed with the solution of bichloride of mercury, described under the bed-bug remedies, and this will be particularly useful behind loose wainscotings and baseboards.

Roach powders and poisons are usually unsatisfactory, as a sole reliance, especially against the black beetles or oriental roaches. Against the croton bugs a mixture of equal parts of sweet chocolate and powdered borax, ground up together in a mortar, is about as good as anything I know of. Powdered sugar is sometimes used instead of chocolate, or all three may be used together; bakers' instead of sweet chocolate being then employed. The roaches are after the sweets and incidentally get the borax, which is fatal to them. Quite a number of the fatal foods and roach destroyers sold by druggists are modifications of this prescription. It can be spread on pantry shelves or wherever the roaches are usually found; but it is more readily eaten from pieces of slightly moistened bread.

Phosphorous paste is also a good destroyer, and this reaches the oriental roaches more readily. In any case moisture is needed as an attraction, especially to the large species. The croton bugs are more apt to run in dry places and to feed on dry foods. The phosphorous paste may be bought ready made, or may be prepared by mixing from 1 per cent to 2 per cent with sweetened flour paste. Spread this on bits of soft or moist bread, and for the oriental roaches place among the edges of the baseboards or on a damp dish rag. A dish rag or damp towel, or even a damp mop, on a kitchen floor, will attract every roach in the room, and they will reach the bait there sooner than anywhere else.

A variety of roach traps are sold, all built on the principle of making it easy to get in and hard to get out. All of these are more or less effective and are useful to reduce the number of the pests in connection with the measures already recommended.

A very simple trap is a large dish pan, the deeper the better, with a foul moist dish rag in it. Set up sticks of lath or card board on an easy slant from the floor to dish, so that there will be no difficulty in getting to the edge of the pan and over the dish cloth. First thing in the morning pour boiling water over the rag to kill the roaches hiding under or in it. The fight should be continuous and persistent, and by all the suggested means until not a specimen remains. After that keep watch for new introductions and kill off every specimen seen.

A very simple Australian method is recorded by Mr. Marlatt in Circular 51, second series of the United States Department of Agriculture. He mixes plaster of Paris, one part, and flour, three or four parts, in a saucer and places it where the roaches abound, with another flat plate near by containing pure water, both supplied with several bridges to give easy access, and one or two thin boards floating on the water, touching the margin. The insects readily eat the mixture, become thirsty and drink, when the plaster sets and clogs the intestines. The insects disappear in a few weeks, the bodies no doubt being eaten by the survivors. This method needs little attention after the mixture has been once prepared, and requires only keeping up the water-supply.

Emphasis should be placed on the point that the best time to make the campaign is in the early part of the season, before the egg capsules are developed, and every female with an egg capsule should be ruthlessly destroyed so as to prevent increase.

Ants.—There are three if not four species of ants that occasionally get into the houses; all of them are small, and one red and one black species are very small indeed. In a general way they infest kitchens and pantries and get into foods of almost any kind, manifesting a special fondness for sugar and other sweet things.

The medium sized red form is the true house species, making its nests behind the plaster, wainscoting or baseboards, behind mantels, under hearthstones and, in fact, wherever there are cavities with external openings. As the insects are so small the narrowest crack or opening will serve, and their nests are, as a rule, beyond reach. The other species may nest indoors or may have an outside nest, simply foraging indoors. In the latter case, when the outdoor nest can be located, it can sometimes be easily destroyed and the whole trouble eliminated.

Ants live together in large colonies in which most of the individuals are workers or wingless, dwarfed females, unable to reproduce their kind. The perfect or reproductive females are more than twice the size of the workers, usually darker in color, with a much larger, heavy abdomen. They lay all the eggs that provide for the increase of the colony and are not usually seen running about with the workers. In the early summer winged males and females are produced, which leave the nest for a marriage flight. The males die, the fertilized females strip off their wings, which are of no further use to them, and seek a convenient shelter to start a colony. The eggs are minute, whitish ovals, which hatch into helpless grubs that must be tended and fed by the mother when the colony is newly started, and afterward by the workers in older establishments. During the winter the ants are usually dormant except in thoroughly warmed houses, and even here none of those having outside nests will be found.

Ants dislike the odor of carbolic acid and of naphthaline, and they can usually be kept away from substances that it is desirable to protect in infested localities. Injecting dilute carbolic acid into crevices from which they are seen to issue has a tendency to drive them away, and gasoline may be used to the same end. If the nest can be located and gotten at, the whole colony may be destroyed with boiling water, gasoline or even kerosene. If not, it means a long and persistent campaign upon the colony with baits.

It often happens in moving into strange houses one finds ants have established themselves. In all cases the pests may be gotten rid of by setting out some specially attractive food near their runs and destroying it when fully covered with the insects. A piece of raw bone with little adhering scraps of meat and blood will become covered in an hour or two, and when so covered it may be dumped into the stove. Even the brown paper in which the meat is sent from the butcher may be set out, baited with a little meat scraping and crushed into a loose wad. In all cases the whole thing should be lifted without disturbance and dumped into the fire without giving any individual a chance to escape to the nest. This kind of bait even attracts the females and a steady campaign for a few days causes a frightful destruction in the colonies. It is usually a matter of two or three weeks before there will be a sudden and complete absence of specimens at the baits, and then for months not an ant will be seen. This sort of campaign has been advised many times and in almost every case success has resulted.

Instead of the raw meat bait, sugar sponges will answer. Two medium sized sponges should be provided, and one of them dipped in thin syrup or sugar water and squeezed nearly dry. Set it on a plate turned upside down where the ants are most abundant, and it will soon become filled with insects. Then prepare the second sponge in the same way and substitute it for the first, which should be removed and at once dropped into boiling water. Wash number one thoroughly so as to get rid of all the dead ants, and it will then be ready to replace number two, when that in turn is filled with the insects. If there are only a few colonies close together, a very few days will answer to destroy them. If there are many, and they are situated in different parts of the room or house, a longer time will be required. It is not probable that the colonies are really destroyed; but it seems rather as if the ants, frightened by the inexplicable disappearance of so many of their fellow-workers, simply abandon the place. In some instances, of course, where the females are destroyed with the workers, the colonies thus left headless simply disperse and the remaining worker perish.

Not strictly pertinent, perhaps, to the title, is the subject of ants in lawns and in roads or pavements. The small mound builders in brick walls or between flaggings can usually be reached by pouring kerosene or gasoline into the openings of the little hillocks. The large ants that sometimes make considerable nests in lawns, may be reached with bisulphide of carbon. Punch three or four holes, five or six inches deep, with a thick cane into as many parts of the nest, pour two ounces of bisulphide into each and close the opening with the foot. The fumes of the bisulphide follow the galleries and kill off larvæ and pupæ as well as adults. A very large nest may require more material then recommended, and as the grade of bisulphide that may be used for this purpose is not expensive, a liberal application will do no harm. The bisulphide acts better when the ground is somewhat damp than when it is very dry; but it should not be water-logged, as after a heavy rain.

Carpet Beetles.—Two species of what are known as carpet beetles occasionally become troublesome and the most common of these is the parent of the so-called buffalo moth. The term moth is utterly inappropriate in connection with this insect and was derived from the habit of the larva, which eats woolens somewhat like the larva of a clothes moth, while the term Buffalo is due to a fanciful resemblance of the anterior tuftings of the larva to the name of the buffalo.

The beetles are broadly oval, a full eighth of an inch in length, mottled with bars of white scales on a black ground, and with a line or streak of red scales down the middle of the back. They winter normally under the bark of trees and in similar outdoor shelters, but may on rare occasions be found moving about actively indoors during that season. In the spring the insects frequent the earliest flowers and may then make their way indoors to lay their eggs.

The larva is a stout though active grub about one-quarter of an inch long, covered with stiff flattened hair of a brown color, forming tufts at the sides and longer ones at each end. It feeds on woolens of all kind, but prefers carpets or fabrics laid on shelves, so it can get under or between the layers. It will not attack clothing hanging in a closet under ordinary conditions. In carpets it eats irregular holes along the edges and, according to Howard and Marlatt, has a tendency to feed along the lines of a floor crack, cutting long slits. Complaints sometimes come from country stores of damage to blankets and rolls of flannel goods on the shelves. There may be two or three broods of the species during the summer, and beetles may be found on the windows until November. In heated rooms larvæ are occasionally found in mid-winter; but that is rare.

Another species which is much more rare is known as the "black carpet beetle," because of its color. It is longer and more slender than the previous species and is not so much found on flowers. The larva is altogether different in appearance—light brown in color, smooth in appearance and tough and horny to the touch; it is almost cylindrical in form and tapers toward the hinder end, where it is furnished with a brush of long hair.

Carpets infested by these insects should be taken up, cleaned and, if possible, steamed, to destroy both eggs and larvæ. The floors should be thoroughly cleaned and the cracks should be treated with gasoline. When relaying, use tar paper around the edges or under the whole carpet. If for any reason carpets cannot be taken up, use gasoline liberally at all points where infestation is apparent, applying enough to soak the fabric and the floor below it. Repeat in a week and watch closely for new points of infestation.

Rugs are rarely attacked, and even a carpet not nailed down is not so likely to be troubled, particularly if it lacks even an inch or two of reaching the baseboards. The use of naphthaline crystals as a repellant under the edges is sometimes advised, and this may be employed if the odor is not offensive.

In store stocks it simply means continuous vigilance, the liberal use of gasoline to destroy larvæ and beetles, and the use of naphthaline as a repellant. Casing rolls of goods in cotton bags serves to protect them and even a tight paper wrapper will answer the purpose.

Moths.—Clothes moths are among the most particular enemies of the good housewife, and nothing is more calculated to stir her into sudden activity than the vision of a little fluttering tan-colored creature in the twilight or in a lighted room. And when the creature flies out from among the clothing hung thickly in a closet, there is disturbance of mind as well as an energetic attempt at destruction. And yet these little fluttering moths, or millers, with glistening narrow yellowish wings, measuring not over one-quarter of an inch, are harmless in themselves. They not only do not feed upon clothing, but are absolutely unable to feed at all. It is not the moth, therefore, that does the damage, but the little caterpillar that produced the moth, and the presence of the flying insect is a danger signal or warning that damage is to be expected unless precautions are taken.

These little moths, or millers, lay their eggs in woolen or other animal textures, like fur and feathers of all kinds, and rarely attack either silk or cotton. The latter is a vegetable product and, like linen, is practically exempt from moth attack. At a pinch, the caterpillars will subsist on animal products other than fabrics, but in the household, woolen, fur and feather goods, whether on the floor as carpets, on the walls as hangings, or in trunks or closets as clothing, are the principal objects of attack. The eggs are very minute, whitish in color and are usually laid directly upon the material on which the larva afterward feeds; but they may be laid in crevices of trunks, boxes or closets containing woolen or other susceptible goods, if the insect cannot get at them directly.

The moth is nocturnal in habit and shuns the light, therefore dark corners and closets are danger points, as are also the crevices of upholstered furniture and the edges of carpets behind furniture, especially upright pianos or other heavy, rarely moved pieces.

From the egg a minute white caterpillar hatches in about ten days and this begins almost at once the construction of a little case or cover made out of fragments of the tissue on which it feeds, held together and lined with fine silk. As the insect grows, this case is enlarged from time to time, and it curiously illustrates the insect's preference for certain colors where there is an opportunity for choice. In an infested carpet certain reds will always be eaten out before any other colors are touched. The length of time passed in the larval stage varies with the locality. No breeding goes on during the winter. When the caterpillar is full grown, it frequently leaves the fabrics upon which it has been feeding and crawls, carrying its case with it, up the walls of closets or rooms to corners or protected places, where it fastens the case permanently, retires within it and closes the opening preparatory to changing to the pupal stage. Before changing to the adult or moth stage the pupa wriggles partly out of the case, and so the empty shell remains after the moth has left it.

This is another of those cases where prevention is better than cure, and our efforts are mostly to prevent clothing, etc., from becoming infested rather than destroying the insects after they once get into fabrics. Clothing in continuous use never becomes infested, nor do carpets regularly and thoroughly swept, or rugs turned and swept at least once in two or three weeks during the summer. Curtains and portieres should be frequently spread out and thoroughly brushed, and should never be allowed to be folded back in one position for weeks. Upholstered furniture should be taken out into the sunlight occasionally and thoroughly brushed out in all folds and corners.

Where carpets are tacked down they usually become infested along the edges, and when feeding is discovered a liberal use of gasoline is indicated. This material does not injure fabrics and leaves no residue, so its use is quite safe.

Trunks or boxes in which clothing is to be stored for the summer should be thoroughly cleaned and treated with gasoline, and then it should be made certain that they are tight enough to keep out young caterpillars, should moths be tempted to lay eggs on the outside, along the joints or seams. The clothing to be packed away should be clean and should be first beaten and brushed thoroughly. It is well, in addition to sprinkle naphthaline crystals between the layers of clothing, for the moths keep away from the odor, and the larvæ, while they are not killed, do not seem to feed much. Material packed in tight pasteboard boxes and sealed by pasting paper strips over the cover junction, is safe if it was clean when put away. A good way to keep coats, cloaks and other garments is to tie them in long paper sacks or sound, close, pillow cases, and hang free in an attic. Wrapping in newspapers is almost as good, provided at least a double wrapping is made. The young caterpillars will not eat through paper, and if there are several wrappings will fail to find their way to the garments. In fact, the essential points are, uninfested material, in the first place, an uninfested tight receptacle or a covering of linen, cotton or paper so complete as to prevent the insects from getting through it.

If clothing must hang in closets or wardrobes without protection the closet or wardrobe should be thoroughly cleaned out in April, all the walls should be swept down and the woodwork should be treated with gasoline. At intervals of three or four weeks the clothing should be overhauled and the closet walls examined for signs of moth. If there is any infestation, some cases are almost sure to be found on the walls, and then it means the thorough overhauling of closet contents, airing and brushing, and a free use of gasoline.

Moths should be killed, if possible, whenever they are noted, and, of course, all cases containing caterpillars should be carefully gathered and destroyed. Aside from this and a free use of gasoline there is no reliable destructive agent. Repellants alone will not protect clothing or other fabrics, and a dependence on camphor, moth balls, tobacco or similar materials will prove more or less unsatisfactory. Nevertheless, in connection with tight receptacles or coverings they are useful, and naphthaline is as good as any.

There will be no development of the insects at any temperature below forty degrees, hence it has become quite a practice to place furs and other expensive garments in cold storage, where they will be safe whether infested or not. By attention to the principles here set out, a careful housekeeper will be able to avoid trouble; there is nothing that will help a careless or neglectful one.

Bed-Bugs.—These insects occur everywhere but are more common in cities, towns and villages than they are in farm-houses, and in some villages they seem to be entirely unknown. They occur not only in houses but in railroad cars, in steamboats and other public conveyances and, while they are essentially nocturnal, they do move about to some extent during the day. Specimens are often seen crawling on the clothing of passengers in railroads and trolley cars, and any person using the usual methods of public conveyance may introduce the pests into the home. There are, of course, many other methods of introduction, not the least important of which is in the servants' quarters, and no matter how careful the housekeeper, occasional infestation will occur. In hotels, boarding-houses and tenements the matter is more serious, and occasionally rooms or entire houses become almost uninhabitable.

The full-grown insect is about one-quarter of an inch in length, broadly oval in shape and very flat; so flat and thin indeed that it is able to get into the smallest crack or crevice, and the body is soft and flexible enough to turn a sharp bend in the crack or opening. The creature has no wings; but has little shoulder pads that mark the places where wings are attached in allied forms. Normally they are red-brown in color and have an unpleasant buggy odor that becomes apparent when they are crushed or even handled.

At night the insects make their way to any inhabitant sleeping in the room, and after feeding they go again into hiding—in the bed if there are suitable places, anywhere else in the room if there are not. They get behind baseboards, picture mouldings, loose wallpaper, picture frames, in the crevices of chairs and other furniture, and in fact wherever there is an opening to crawl into. After a full meal of blood the insect remains quiet for several days, occasionally voiding a spot of black excrement which, when it occurs on the bed linen or on some exposed part of the bedstead, at once informs the experienced housekeeper of the presence of the pest.

The eggs are whitish in color, oval in form and are laid in little masses in the usual hiding places of the adults. They hatch in about eight days, and the resulting young are like the adults except in size, and until they have fed, are whitish and almost transparent. Their rate of growth depends upon their ability to get food. They can live for weeks without it, but if they get access to their prey regularly, it takes them from seven to ten days from one molt to another. They molt five times, so a minimum period of forty-five days from egg to adult is required, and during that time the insect must have fed at least five times. A single female may lay several batches of eggs, so that when once started multiplication is extremely rapid.

Usually, gasoline is all that is necessary to get rid of the pests when they are confined to the beds or bedrooms of an ordinary dwelling-house or residence; but it must be a liberal and at least a duplicate application. The modern brass or iron bedstead is easily examined and kept clean; the old-fashioned wooden beds, especially some of the large heavy articles, give an abundant chance to hide and are correspondingly difficult to clean out.

On several occasions more or less badly infested bedrooms have been treated as follows with good success. Provided with a gallon can of gasoline and a long pipette with a large rubber bulb—an oil can with a long thin spout might have done as well—the bed was taken apart and every crevice, crack and joint filled with gasoline. The mattress was dosed at all the tuftings. Gasoline was poured along the picture moulding and squirted behind the baseboard. Every picture was taken down, the back was removed and the edges of the frames were treated. Every chair was examined and gasoline was used in every opening. The bureau, washstand and other furniture was as carefully handled and all the woodwork around the door and window frames received its dose. Gasoline hurts nothing in the way of fabrics or papers, so it was safe to use it freely, and it is death to every bug that it reaches. It does not destroy eggs with certainty, however, therefore a second treatment is necessary about ten days or two weeks after the first; but that need not be nearly so thorough. Where no traces of eggs are seen on the furniture, no second application need be made; but in all crevices into which it is impossible to see, the application should be as well made as before.

Where beds are likely to become infested, as in boarding-houses and hotels, a very large measure of exemption may be secured by using corrosive sublimate (bichloride of mercury) dissolved in water and alcohol. Have the corrosive sublimate powdered—say two ounces—and add a pint of water; let it stand a day or two, shaking occasionally, until the water has taken up all the material that it will dissolve. Add an equal quantity of alcohol, shake up thoroughly and then apply with an oil can or pipette into every crevice and crack in the bedstead. This is an intensely poisonous mixture and should be used with that fact in mind. The combination of alcohol and water soaks into the wood or evaporates very rapidly, leaving a thin powdering of very finely divided corrosive sublimate as a covering in the crevices. This is death to every bug that gets into it, and so a bed may be kept free for a long time. It is as effective a killing agent as gasoline, but much more expensive and, owing to its poisonous and corrosive nature, unsuited for free use. It should never be used on brass or copper.

Where rooms or entire buildings become badly infested more heroic measures must be resorted to, and fumigation with sulphur or hydrocyanic acid gas is indicated. The methods of doing this are described elsewhere.

Fleas.—Fleas are not common household pests in New Jersey, but occur often enough to make it convenient to know how to deal with them. The species that specially attacks man is rarely, if ever, found, the common cat and dog flea being almost invariably in fault. This will get upon human beings and will bite readily, especially about the ankles; but it does not remain on the body for any time after feeding, and does not find natural conditions on the smooth, comparatively hairless skin of man. Cats and dogs are infested by the same species, and when there is ready access to these animals humans are rarely attacked.

It sometimes happens that after a house has been shut up for a few weeks during the summer it will be found thoroughly infested with fleas when opened up again, and there are always a few very unpleasant days until the insects are gotten rid of.

Although fleas pass their adult life on the animals attacked by them, and are thus loosely termed parasites in that stage, the early or larval stages are passed in altogether different surroundings. The female usually lays its eggs in the bed or lair of the animal that it infests, and the larvæ that hatch from them within two or three days are very minute, white, worm-like creatures without eyes or legs, that live on dry animal and vegetable matter of

Work of Pear Thrips. 1. Black Tartarian Cherry Blossoms Killed by Adult Thrips and Leaves Injured by Young Thrips. 2. Bartlett Pear Injured by Adult and Young Thrips.

(See page 45.)

all kinds. The excretory and shed refuse matter in a neglected kennel or box, or on a sleeping rug, offer ideal conditions; but a little heap of moist sawdust, or even the dust and dirt in the spaces between flood boards, will answer as well. It usually takes about ten days or two weeks for these larvæ to become full grown, and then they spin thin silken cocoons, in which they change to pupæ. In less than a week, usually, they complete the change to adults, and these seem to be able to reproduce without blood food.

House infestation usually comes when the place is shut up early in summer and the sleeping quarters of the dog or cat are left as they stand. Unless the animals using the bed were absolutely without fleas, eggs or larvæ are almost certain to be present, and these are thus enabled to mature undisturbed. The resulting adults will scatter in their search for food, and later broods of larvæ will develop in organic matter anywhere throughout the house. During a two months' vacation three broods may develop, and the returning family will then find matters lively in more ways than one. Usually the lowest floor is worst infested, and rarely do the insects get above the second story.

As the family pets are primarily responsible for the infestation, they can be made use of to reduce it, using the preference of the fleas for such animals as the lure. First wash the animal with carbolic soap to destroy all the insects then infesting it—dogs are easier to wash than cats, and the latter may be thoroughly dusted with fresh pyrethrum well rubbed into the fur instead—then allow the animal to run throughout the infested part of the house for twenty-four hours; wash or dust against to destroy the new infestation, and continue this until all the adults have been trapped and destroyed. Meanwhile clean thoroughly all the infested rooms and remove every accumulation of organic matter that might possibly serve as breeding place for the larvæ. Floors should be scrubbed or mopped, and then, after they are dry, gasoline should be run into every crack between boards and under baseboards to kill larvæ and pupæ. In the infested laboratory ten gallons were used in two days, but at the end of that time there were mighty few fleas left and no larvæ remained to provide for a new supply. The flea larvæ seem to require undisturbed conditions for their proper development, hence they never multiply greatly, if at all, in rooms or places that are frequently cleaned, swept or disturbed.

The bed, box or other resting place of the house dog or cat should be cleaned or shaken out and exposed to the sunlight at least once in ten days, and better once a week.

Lice.—These are, more strictly speaking, parasites, infesting both man and domestic animals; but as certain species are almost or quite confined to man, and as children may become infested from casual playmates, a few words on the subject may not be amiss.

The commonest species is the so-called head-louse, which derives its name from the fact that it is most generally found among the hair of the head and feeds by puncturing the skin and sucking blood. The eggs are attached to the hair, and so tightly that ordinary combing and brushing will not dislodge them. They are commonly known as nits, and are quite large enough to be seen on careful examination. These nits are also quite resistant to any ordinary insecticide applications, and where there is a large supply, infection may continue for some little time after treatment is begun.

As the breathing pores of these insects are not well protected, they may be reached by greasy pomades or ointments, or even plain lard, liberally applied. Pomade vaseline is the cleanest of these materials, and should be liberally applied after the hair and head have first been thoroughly combed and washed. Such parasites as have not been removed by the mechanical measures employed will become choked by moving among the greasy hair. This application must be repeated at intervals of three or four days for ten days, by which time all the nits will have hatched. So long as any eggs remain unhatched the danger of reinfestation remains.

Another remedy, said to be very effective, is an infusion of larkspur, with which the head is to be washed. This also must be duplicated to reach the insects as they hatch, and has no advantage over the simpler greasy applicants.

A second species, much less common, is the body-louse, which lives in the seams of clothing and after feeding retires into hiding. This is essentially a pest of the camp, where the soldiers know them as gray backs, and of all places where men and women are crowded together with insufficient clothing or without due regard to cleanliness. These lice lay their eggs in the seams in which they hide and so tough are they that they will resist ordinary boiling in water for a considerable period.

Under normal household conditions these insects never become numerous, but, as with bed-bugs, any member of the family using a public conveyance may bring them in. When a garment has become infested, the parasites should be located and destroyed, if possible. If not possible, the clothing should be boiled or steamed to destroy both insects and nits. If that also be impossible or inadvisable, then smear the inside of the seams with mercurial ointment. It does not require much, and it kills by clogging and poisoning. It may be necessary, if the garment is badly infested, to renew the application after a few days, until all the eggs have been hatched.

The third species is known as the crab-louse, from its broad shape and sprawly legs, and this inhabits the coarse hair of the body, on the breast, under the arm pits or in the pubic region. This also lays its eggs on the hair, and the structures of its feet is such that it can hold to a hair so tightly that this can be pulled out more easily that the insect can be dislodged. These insects may be picked up in the toilet rooms of hotels, railroad cars or other places open to the public at large, and as the insects are hard biters they often cause a great deal of irritation.

Mercurial ointment, thoroughly and frequently applied at the infested points, is the only reliable remedy, and it may require ten days or two weeks before complete riddance can be obtained. Ordinary care and cleanliness will preserve an adult from all these pests or will enable the prompt recognition of the infestation. Children have to be watched, as they are not always choice in the selection of their playmates, and in public schools are often brought into close contact with others who are not so well looked after. In a general way, be clean and careful to prevent infection; if infection occurs be prompt to act, and use a greasy material to come into contact with the parasites.

Flies.—A number of species of flies occur in houses, but most of them do not breed there. The largest percentage consists of the common house or typhoid fly, and this is a nuisance in every sense of the term. It is not only an annoyance, but is actually dangerous as a carrier of any sort of germ disease. The adult gets into everything, walks over everything and feeds on or at least tastes almost everything. Germs may be taken up on the hairy pads of the feet from excrementitious matter, expectorations or other waste, and may be carried to food or directly to the individual. From a sick room, flies should be most rigidly excluded.

House flies lay their eggs on and their larvæ live in excrementitious material of many sorts; but the favorite food is horse dung, and in a small quantity of this a great number may develop. Sometimes they are found in garbage pails or barrels; but these are more usually used by other species. The larvæ of flies are maggots, and it takes only a little over a week for them to pass through all the stages, from egg to adult. Development, therefore, takes place outdoors as a rule, and only the adults come into the house. They hibernate there if given a chance, and in a well warmed residence flies are never entirely dormant.

Another common species is somewhat larger than the house fly, metallic green or blue in color, and this is attracted to and breeds in garbage and animal and vegetable refuse of all kinds. If a garbage pail is left uncovered or loosely covered in summer for three or four days, it will be found swarming with the maggots of this species, ranging in size from those just out of the egg to half grown or more. These flies are not so obtrusive indoors and do not so usually bother the person or get into cooked food.

Larger yet, and comparatively more rare, is the blue-bottle, or blow fly; a dull blue, stout, bristly species which makes a loud buzzing noise and is more annoying from that cause than from almost any other. The larvæ or maggots of this species develop chiefly in decaying animal matter. A dead mouse will support a dozen; a dead rat will mature a large brood. All these flies are actually scavengers, hence they have a real function and the best way to deal with them is to remove the cause for their existence. Allow no decaying matter in or close to the house, and keep all garbage receptacles so tightly covered that the flies cannot get at the contents to lay eggs.

Flies do not like the dark, and will fly out of a small lighted opening, if the remainder of the room be darkened. They are attracted by food odors, hence are most numerous in kitchens and dining-rooms. Give them no chance to get food and they will not stay long; hence in parlors and sitting-rooms kept darkened and free from food particles, flies are rarely seen.

Besides these larger species which may be kept out by care and screens there are often found, especially in late summer and early fall, very small flies, with bright red eyes. These are the so-called pommace flies, and they are attracted to and develop in fermenting fruit juices of all kinds. A basket of over-ripe grapes, or an apple or pear, beginning to decay, attract a swarm from the surroundings at very short notice, and with the disappearance of the material that attracted them the flies also disappear.

Meal Worms.—Flour, meal, bran, oatmeal, cracked, and even whole corn, are apt to become infested with meal-worms of varying size, from the slender little grubs of the saw-toothed grain beetle, which scarcely exceed an eighth of an inch, to the inch-long, almost cylindrical larva of the Tenebrio species. The latter, yellow and dark, are best known as meal worms, and are more usually found in barns and stables, while the small species are more general in the pantry and flour closet. The insects are usually brought into the house with the purchased packets of corn, oat or other meal, in cracked-dust and other mill products, and when they are once established it is not always easy to get rid of them altogether.

Practically, in the household, it means extreme cleanliness; getting rid of all infested material and keeping the supply in tight boxes or packets. It will be better to have on hand or open only enough for current use, and above all things have no remnants in the box in regular use. I have seen a glass jar badly infested simply because it was never quite emptied. When the supply got to within an inch or half an inch of the bottom a new lot was added, and the infested material at the bottom always served to supply the material in a very few days. With this one point kept in mind, one or two-quart glass jars, like those used for preserving fruit, make excellent receptacles for the current supply of peas, beans, lentils, the various meals and similar products.

In barns, stables and granaries equal cleanliness is imperative, and the great point here, also, is to always empty and clean out bins, mangers and other receptacles completely, and never allow any material to lie around in corners for weeks or months, open to any stray beetle that comes along.

Those slender meal-worms having a small, yellow head and three pairs of short legs anteriorly, are all the larvæ of various species of beetles, and in the house or in warmed barns or stables they breed continuously. In cold barns and granaries there is no breeding during the winter, and in these, when large quantities of material become infested, the use of bisulphide of carbon is sometimes indicated.

Another type of larvæ is found in the meal moths, of which a number of species occur in food supplies. These larvæ are really small caterpillars, and they have, besides the three pairs of legs anteriorly, a series of four pairs of short legs at the middle of the body. Most of these caterpillars spin a certain amount of silk, and some of them live in regular silken tubes. One of the most common species, the Indian-meal moth, which is only a little larger than and is often mistaken for a clothes moth, attacks also dried fruits, nuts and other vegetable products. Walnuts are not uncommonly infested, and they have been found in boxes of figs from the Orient and of prunes from California.

The same general recommendations that were made for the other meal-worms apply to these as well. These meal moths, though not often troublesome in the house, sometimes becomes veritable pests in barns, mills, granaries and elevators, and require the most active treatment for their destruction. This, however, is not a point meant to be covered here.

Larder Beetles and Skippers.—Wherever smoked provisions are stored in any quantity or for any time, or wherever cheeses are stored, there is a tendency to attract a certain series of insects that feed in the adult or larval stages on such materials. The skippers are very small, slender maggots that move about actively and have the habit of drawing themselves up into a loop, then springing forward with a jerk that sends them for some little distance. It is this habit that gives them their common name. They are found in cheeses, especially when they get a little old and soft, and in the fat of ham and bacon. Sometimes even the cased ham or bacon received from the packing-house will be found infested, and in pantries that are not kept clean the insects may develop in the greasy matter on the shelves or in cracks and crevices. Hard cheeses are not so liable to attack as the soft, fatty types, and those that develop a distinctive odor are especially subject to attack.

These skippers are the larvæ of small, brownish-gray flies, very like the pommace flies in general appearance, and these flies lay their eggs in little masses, whenever they find opportunity, on any fatty material. It is the fat that they are after, not the meat, and they do not impart any dangerous quality to the meat itself.

Larder beetles are after the same type as the carpet beetles, and belong to the same natural family, but they are much larger and usually mottled with gray scales. Their larvæ are hairy, brown or blackish worm-like creatures, and feed on any sort of dry animal product, smoked or fresh. They are not common in city houses or pantries, but are very apt to be present in farm-houses, where provisions are stored in larger quantity and for a longer time.

The larder beetles are so large that they are easily seen and easily kept out of pantries by tight doors with small meshed wire screens. But where their presence is noticed, it is better to trap them, as otherwise they may lay their eggs as near to the food as they can get, and the minute young can get through the screens or the joints of the pantry doors. By placing a ham bone with some scraps of adherent meat, or an old ham or bacon rind on a shelf or box near the pantry, all the beetles will be attracted, because it is most accessible, and by looking under and on this trap every two or three days and destroying the insects found there, the brood will be gotten rid of and the real provisions will be protected.

The skippers are harder to deal with. Soft cheeses must be protected by tight receptacles. Infested smoked meats must be cleaned, *i. e.,* the infested fat scraped off, the pantry must be scrubbed with boiling hot soap suds and soda to get rid of all the old grease, and it must then be made as tight as possible; the finest brass wire mesh being used on the doors or wherever the ventilating panels are situated. It is a good thing to fumigate with sulphur if the pantry is in the cellar, to get rid of such adult flies as may be present.

It goes without saying that the cleanest and best kept and built provision houses are most likely to be free from the pests. Meats may become infested even while smoking, because the flies do not seem to mind smoke, hence it is important that smoke-houses be as clean as possible to prevent the breeding in floor cracks and elsewhere where greasy material may lodge and remain.

Drug and Cigar Beetles.—There are two species of small brown beetles, not over an eighth of an inch in length, that are occasionally found in dwellings, but more frequently in stores and warehouses. They attack dried roots, seeds, cane and rattan work of all kinds and will even attack books, gun wads, cigars, plug tobacco and the greatest variety of vegetable products. The drug beetle derives its name from the fact that it seems to prefer the stored roots, herbs and samples of the apothecary; the poisonous hellebore and belladonna being as readily taken as the aromatic licorice. Signs of the presence of this insect are little round holes in the infested material, and fine dust at the bottom of the jar, drawer or other receptacle containing it.

The tobacco beetle has very similar habits, but seems to prefer tobacco to all other materials. If a box of cigarettes becomes infested before it is sealed and remains unused for a few months, little round holes may be found in every cigarette in such numbers as to make them unsmokable. Cigars are as likely to become infested and old stock is very apt to be more or less damaged.

The larvæ of these beetles are small, fat, white grubs, nearly smooth for the drug beetle, densely covered with stiff brown hair for the cigarette beetle. Their feeding habits are very much alike and in some places one, in other localities the other is most common. As to methods of dealing with them, that depends much on the material that is infested. Rattan, basket or willow work is best soaked in or with gasoline, which penetrates the burrows and kills all stages except, possibly, the eggs.

Infested roots and the like cannot be so treated, of course, and in most cases the best thing to be done is to use up the material to the best advantage possible and thoroughly clean out and fumigate the receptacles. For this purpose bisulphide of carbon will be found most useful, and at the rate of a dram to a cubic foot of space it will kill all the insects in a tight receptacle within a few hours, whether as larvæ in the galleries of infested roots, or as adults moving on or hiding among them. The conditions under which these insects may occur are so varied that it is almost impossible to give any universally applicable suggestions. Each case must be dealt with according to its own peculiar features, and the combination of cleanliness, gasoline and bisulphide of carbon will usually serve to give relief.

Termites, or White Ants.—They usually attract attention in early spring, when swarms of dark brown or blackish, flattened ant-like creatures may be noticed fluttering about with large frail wings, and the center of the swarm may be a fence-post, an old board or even a floor beam or studding. These flights usually occur quite early in the day and by noon little or nothing remains of the swarms. If, when the swarms are noticed and the center is discovered, close examination be made, the insects may usually be discovered emerging from a hole or crevice in the wood, and if the log, post or board be further examined it will usually be found eaten out or burrowed and filled with large numbers of yellowish-white, flattened, wingless creatures, about one-quarter of an inch in length, with soft, bluntly terminated bodies and large heads. These are the real white ants or termites, the brown, flying forms being the mature sexed individuals which are intended to form new colonies. If we gather a lot of these white creatures, we will note that some of them have much larger heads and long, pointed, brown mandibles. These are soldiers, the others being the workers or chief inhabitants of the colony.

Termites are not true ants at all, but have a somewhat similar social organization, and the common name is expressive enough to be recognized in general use. A colony of termites consists mainly of workers, which are dwarfed males and females that never become able to reproduce, that never become winged and that are blind, never coming voluntarily into the light of day. A small percentage are soldiers, whose function is supposed to be the protection of the colony, and these are also blind, sexually immature individuals that never become winged. There is a female or queen at the head of each of these colonies, whose sole business it is to produce eggs, and some of these eggs annually produce a swarm of fully developed males and females that in early spring leave the nest in a body, never to return. These insects are wood-feeders, and, working as they do, ever in concealment, they may cause a great deal of mischief before their presence is discovered. They feed only in wood, and usually in somewhat damp wood or at least in damp surroundings, but sometimes they carry their destructive work even into dry timber at a long distance from the center of the colony, ever burrowing under cover and never making openings to the light except as exit for swarms. When once the woodwork of a building becomes infested they are hard to get rid of, because of the difficulty of locating the source from which they come. This may be and often is an old stump outside of the infested building, or a partly buried beam, sleeper or bedplate. If the building is set on posts, these are likely to be the seat of the colony, which is never located in the earth itself, though galleries may be run through it and under stones.

Remedial measures are few. There is no way of reaching them by stomach poisons and contact insecticides must be entirely relied upon—even hydrocyanic acid gas fumigation is ineffective. Where the insects infest fence-posts or rails, make an opening into it and drench with gasoline. This will penetrate into the burrows in every direction and will kill everything with which it comes into contact. Bisulphide of carbon is even better, as its vapor will penetrate into the ground itself and will follow the galleries, where liquids would be lost long before they got far enough to do much good. This application may be followed by one of creosote or other similar preparation, which acts as a preservative and at the same time is repellant to the insects.

Where interior woodwork is infested the problem is less simple, and the effort must be to discover the location of the colony whence the insects come, the search being guided by what has been said as to their general habits. Hot water, gasoline and bisulphide of carbon should be freely used and in extreme cases it may be necessary to tear out part of the infested woodwork and replace it by sound, dry material, and preferably some that has been soaked in some creosote preservative. If possible the ends should be isolated from direct connection with infested wood or with posts that go into the ground, and this may be done with tin, iron or other metal, or even tar paper. Corner posts or other timbers extending into the soil should be imbedded in cement or should have a thick cement wash, the ends being especially well protected. This is one of those species where almost each case of infestation requires special treatment, based on individual conditions, and where only general principles can be indicated.

*Powder-Post Beetles.**—Occasionally the householder is startled to find in a piece of furniture, a mantel, a picture frame or a wainscoting, a number of little round holes, from some of which fine sawdust may come, to indicate that, whatever the cause of the trouble, it is not at an end, and that the extent of the injury beneath the outer shell or surface is a mere matter of conjecture.

The insects in fault here are small, slender, cylindrical brown beetles, known as powder-post beetles, from their habit of reducing to powder the inside of the wooden parts attacked. All the hard woods are liable to be infested, but usually only in the sapwood. Only seasoned lumber is attacked, and if infested material is worked up into furniture or fittings, the insects will continue their work below the outer surface and will emerge in due time, through even a coating of paint, oil or varish.

Heavy coatings of benzine, turpentine or gasoline, as may be indicated, are the only things that can be used in suitable cases. These materials penetrate through the small exit holes, soak into the galleries and kill everything with which they come into contact. Where there is no finish of paint or varnish, a coat of creosote is sometimes useful and tends to prevent further attack. Ordinarily,

* See illustration on page 663.

where in a house a piece of infested furniture or other woodwork has been once cleared, there is no recurrence of the trouble, and I have known several cases where during one season a great number of the beetles issued, leaving small holes all over the frame, wainscoting or mantel, and that ended the difficulty; no additional holes appearing for the two or three years next ensuing.

Centipedes.—One species of centipede or thousand-legged worm is not infrequently found in houses, generally on damp walls or in cellars, but sometimes also in kitchen or pantry and not rarely in bathrooms. It is yellowish-gray in general color, mottled with blackish, rather more than an inch in length, with fifteen pairs of very long, slender jointed legs of which the hind pair look very much like the feelers or antennæ. A full-grown specimen, with legs fully extended, looks on a wall as though it were at least two inches in length, and as it moves over the surface rapidly, its body well elevated, it gives a creepy sensation to most people, and there are many who are actually afraid of it. If an attempt is made to catch it or the creature is hit with a towel or stepped on, it seems to fall apart and resolve itself into a little mass of squirming legs. It is really a most fragile thing and not at all harmful.

So far from feeding on fabrics or stored products, it is really predatory and lives on flies, roaches, silver-fish and any other small creatures that it can find and capture. It runs with great rapidity and none of the ordinary household insects can escape from it. Like most domestic species, it is nocturnal in habit, but is not infrequently seen during the day, especially in cellars.

The bite of all centipedes is poisonous, but it would be almost impossible to induce this species to bite, and it will never do so voluntarily. Any insect will use its jaws to save itself when in danger, and under such circumstances an individual may be bitten, but the results would hardly be more than from the bite of a bed-bug in any case and they would vary in severity according to the general susceptibility of the person bitten.

Being really useful rather than harmful, no efforts to destroy these creatures need be made; but they are not attractive and should be killed when they get in the way during the day. Should there be a bite, a little ammonia, or better phenol sodique, will suffice to allay the irritation caused.

Fish-Moth or Silver-Fish.—The terms fish-moth and silver-fish are applied to slender, silvery white creatures, rather more than one-quarter of an inch in length, with long slender antennæ or feelers, and three equally long and slender anal filaments. They are seen mostly at night, run rapidly, and are very fragile, crushing at the least touch and leaving a silvery powder on the finger. This powder consists of veritable scales when examined under the microscope and gives a sort of warrant for the popular name silver-fish. They run very quickly when disturbed, with a darting motion, and they slip into a crack or crevice at the least alarm. Some of them are most frequently seen in damp places, in basement kitchens or in closets or pantries, and these are somewhat worm-like, smooth, evenly white, tapering quite markedly toward the posterior end. Others are found in dry places—around stoves, in the drawers of desks and pantries—and these are more flattened, less smooth and tapering and somewhat mottled with gray on the back.

These insects feed in starchy material of all kinds, wherever they can get it, and do not attack carpets or clothing under ordinary circumstances. The jaws are small and weak, but they are sharp, and the insects will gnaw the starch from stiff shirt bosoms, the calendered surface of heavy paper, or will eat the paste of the wall paper or starchy material of any kind. They occasionally gnaw the bindings of books, or the gummed labels, and in that way make themselves a nuisance.

No serious trouble is known to occur in households from these insects. They do no good and should be killed whenever seen; but, on the other hand, they are rarely abundant enough to warrant a campaign against them. Naphthaline is usually a repellant and pyrethrum dusted into their hiding places kills them readily. Gasoline is sure death to them, of course.

Book-Lice.—Occasionally the housekeeper gets a scare when she notices among her starched sheets and skirts on the shelves of the closet or in the drawers of a bureau or table, little, white louse-like insects that move rapidly and that seem to be out for no good purpose. They are quite generally mistaken for true parasites, but are only book-lice, deriving their common name from the fact that they are also found among papers in desks, on dusty book shelves and wherever dry paperware is stored or kept.

They differ from the true parasites by their rapid gait, the others moving only at a slow crawl, and by a number of other details that become apparent when the insects are closely examined. They have minute but sharp-edged mandibles, by means of which they gnaw the surfaces upon which they feed, belonging to an order called the *Corrodentia* or gnawers.

Their food is dried animal and vegetable matter, and they occasionally get into collections and cause a certain amount of mischief. When they are found among clothing they are after the starch, and that is their aim also among papers. Paste is also attractive, and where a corner or shelf or drawer has been long neglected, these insects are almost sure to be found. They rarely do any appreciable amount of damage, but are not considered desirable, as a rule.

Clean out infested shelves, drawers or other receptacles; use gasoline freely where circumstances permit; in any case dust clean in all corners and try to clean out all cracks, seams and crevices. When repacking, naphthaline crystals will serve to keep boxes or drawers free from the insects and to some extent this is effective even on shelving. Pyrethrum or Persian insect powder is useful in some cases, and in moderately tight boxes I have found a little chloroform an excellent remedy. They are sometimes common in straw or cornhusk mattresses and in such cases, where the infestation is very bad and the insects are really annoying, the destruction by fire of the mattress filling is the most effective measure.

Cleanliness is always essential if any house, barn or store is to be kept free from insect pests, and this involves not merely sweeping and dusting, but the disposal or keeping under close cover of all food remnants and organic debris of any kind.

In a general way gasoline comes as near to being a universal insecticide for house pests as anything that we have. It kills everything that it touches except eggs, and it hurts neither fabrics nor furniture. It can be poured freely over the edges of carpets or behind baseboards or picture mouldings, and in a few minutes it is gone without a stain. It is decidedly inflammable, however, and must always be used with that point in mind. It should never be used at night, should never be used in the kitchen when there is a fire in the stove, and there should always be an opportunity for the fumes to escape promptly into the open air.

In general, two treatments are required for household insects, because none of the destructive methods reach the eggs. It is quite possible to kill off every adult specimen of a species on Monday and then to find on Saturday a lot of young that have just hatched from eggs laid prior to the treatment.

The most effective material and in a way the simplest in badly-infested spaces is hydrocyanic acid gas. This penetrates everywhere, is deadly to all animal life and requires only that the room to be treated should be so tightly closed as to prevent the too rapid escape of gas.

MANAGEMENT CONTROLLING FIELD CROP INSECTS.

ESSENTIAL FEATURES.

In order to adopt a system of farm management for controlling field crop insects, the life history, habits and food plants of the insects most injurious on the farms in question must be thoroughly known. Unfortunately there is much yet to be learned about these pests but with the information gathered during the last two years a general plan of rotation and management involving our most important field crops can be proposed. Several of these pests have been under investigation during the last few years and special reports of this work will be issued at the end of this growing season.

The following are important features in a system of farm management for controlling field crop insects:

(1) It must be as far as possible a modification of the farm management already in use without eliminating important crops that the farmer desires to grow.

(2) The intelligent sequence of crops that deprive the insects of food.

(3) Methods of cultivation for disorganizing, killing or exposing the pests that are to be controlled.

(4) The upbuilding of the soil by incorporating humus; intelligent and effective cultivation and the intelligent applications of fertilizers.

(5) Selection of seed and proper harvesting.

To follow the same crops with each other continuously increases the facilities for the depredation of insect pests attacking these crops. Not only is an intelligent rotation essential in farm practice, but the winter season should be well provided for. When we leave a corn field undisturbed after harvest, allowing the stubble to remain intact till the following spring, we should not be surprised when our crop the following year is seriously injured by corn stalk borer, corn earworm, or corn billbugs. In view of these considerations and with the available records about the habits, life histories and food plants the following plan of rotation and cultivation is proposed. Only the general principle can be laid down in this bulletin and each farmer must vary it as the situation may suggest. —(Bul. 150 S. Car. Agr. Exp. Sta.)

Plots.	First Year.	Second Year.	Third Year.
Field 1.	Corn Cowpeas Oats	Oats Cowpeas Rye †	Cotton Rye †
Field 2.	Oats Cowpeas Rye †	Cotton Rye †	Corn Cowpeas Oats
Field 3.	Cotton Rye †	Corn Cowpeas Oats	Oats Rye †

† Vetch seed may be mixed with the rye.

In the above table rye is given as a winter cover crop except where oats is used in the rotation, this being chiefly for a section where no systematic rotation has been practiced, rye being a safe crop for the beginning. Where crimson clover or other clovers can be grown these may be substituted for the rye and cowpeas. Before using these in a regular rotation, however, the planter should become familiar with the methods for growing them in order to avoid as far as possible any necessity of letting the fields lie exposed during the winter.

To get a rotation perfect for controlling all field crop insects is impossible because in some cases one and the same pest may be an enemy to two of the main crops used. In a rotation consisting of cotton, corn and oats as the principal crops it is impossible to avoid cotton and corn following each other. This is unfortunate owing to the ravages caused by root lice and wire-worms, though entirely advantageous in cases where nematodes of cotton (root knot) are to be combatted, corn being no important food plant of these worms. In the rotation where cotton and corn follow each other they are separated by rye, which is not a food plant for established corn and cotton pests, at the same time being a good cover crop involving clean culture and a consequent elimination of weeds serving as winter host plants of the insect enemies. This will also tend to eliminate injury from corn earworm and cotton boll worm, owing to destruction and exposure of the winter resting stage in the late fall. The corn stalk borer, one of the best known and most injurious insects to that crop as well as corn billbugs will also be handicapped in passing the winter owing to the fall destruction of corn stubble. This same practice is also advantageous against cow-pea pod weevils which cannot live on rye or oats. While this rotation is intended to be typical, it may be modified to suit the circumstances.

In a rotation the handling of the various crops must be governed by the soil fertility. Whether the given crop should be removed or plowed under for the purpose of incorporating humus must be determined by the circumstances. On account of the comparative scarcity of live stock and absence of a systematic rotation the upland soils in many sections are deficient in humus, a most important factor in insect control. Some of the field crop insects of first importance do their principal, if not the entire damage, to the young plants and such damage is generally more pronounced on the less fertile upland soils. The incorporation and maintenance of humus in such soil is essential for it enables the farmer by the addition of necessary fertilizer to hasten the crops over such danger periods. This is especially true of corn in this state; while easily damaged by insects under adverse conditions, it responds very readily when these conditions are corrected.

Other schemes of rotation may be devised to suit special cases. In the above recommendations are involved the basic principles of good farming. They embody the idea of diversification and clean farming. In planning the farm operations from year to year it is important to consider what effect a given procedure will have upon the increase or decrease of certain insect pests that were destructive to one more of the crops during the past season.—(Bul. 150 S. Car. Agr. Exp. Sta.)

CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable for their multiplication than to destroy them after they are once in possession; and in controlling them, methods and systems of farm and orchard culture have long been recognized as of the greatest value, more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible, of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury. Strong, healthy plants seem to have a native power of resistance which renders them, in a measure, distasteful to most insects, or at least able to throw off or withstand their attacks. A plant already weakened from any cause, however, seems to be especially sought after, is almost sure to be the first affected, and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

The constant cropping of large areas of land year after year to the same staple is largely responsible for the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the enemies of such crops. A most valuable cultural means, therefore, is a system of rotation of crops which will prevent the gradual yearly increase of the enemies of any particular staple by the substitution every year or two of other cultures not subject to the attacks of the insect enemies of the first.

With such insects as the Hessian fly, the squash borers, and many others which have regular times of appearance, much can be done by the planting of early or late varieties or by deferring seeding so as to avoid the periods of excessive danger. Wherever possible, varieties should be selected which experience has shown to be resistant to insect attack. Familiar illustrations of such resistant varieties in all classes of cultivated plants will occur to every practical man, and a better instance of the benefit to be derived from taking advantage of this knowledge can not be given than the almost universal adoption of resistant American vines as stocks for the regeneration of the vineyards of France destroyed by the phylloxera and for the similarly affected vineyards of European grapes in California.

In the case of stored-grain pests, particularly the Angoumois moth, or so-called fly weevil, the chief danger in the South occurs while the grain is standing in shock or stack, after harvesting, during which period the insects have easy access to it. This source of infestation may be avoided by thrashing grain promptly after harvesting and storing it in bulk.—(Farmers' Bul. 127, U. S. D. A. B. E.)

MECHANICAL METHODS OF CONTROL.

In many cases it is impossible to capture some species of insects before they have caused much damage, and if this can be done at the right time it will not require much labor to check future damages.

Catching Insects by Nets, Jarring and Beating.—The few white Cabbage-butterflies that succeed in passing our winters safely and which appear on the wing in spring near the young cabbage plants can be readily caught by small boys and girls with a butterfly net, which anybody can easily make. By preventing these early butterflies from laying eggs none of the later brood can appear. The different species of snout-beetles that infest our plum trees hibernate as perfect insects and visit the trees long before any leaves are found upon them. By jarring the trees early in the morning these insects can be collected upon a sheet of muslin spread under the tree and killed. By beating the young potato vines the beetles that have collected there to eat and to lay eggs can be gathered into a tin pail containing water with a little kerosene oil, and can thus be destroyed.

Catching Insects By Trapping.—Many of the caterpillars of the Codling-moth descend the apple trees to pupate. If a band of folded papers be put around the trunk they will go below the band, where they can readily be crushed. The males of many destructive moths can be collected and killed by confining a freshly issued female under a sieve. Many males will be attracted to the female and will try to reach her, and while thus engaged can be captured. This method is often very effective, especially with our larger destructive moths.

Catching Insects With Light and Baits.—A large number of injurious insects are attracted to strong lights, as may be seen in cities illuminated with electric lamps. By arranging a vessel with water, upon which floats some kerosene oil, under brightly burning lamps arranged in fields to be protected many destructive insects can be caught and killed. By using lights many beneficial insects are also captured, most of which might be saved by using water alone. Baits, consisting of various materials corresponding to the insects intended to be caught, are very attractive to certain kinds. Sugar or molasses dissolved in water and mixed with a little real vinegar attracts the moths producing cut-worms.

Collecting Eggs of Noxious Insects.—In many cases injurious insects can be greatly reduced in number by gathering and destroying their eggs at the proper time. The eggs of Cabbage-butterflies and Potato-beetles can be readily detected upon the young food plants. Eggs of the Tent-caterpillars are prominent during the winter upon the trees that are preferred as food, where they should be collected and burned. The eggs of the Migratory Locusts can sometimes be collected more readily and in larger numbers than the active insect itself.

Burning Dead Twigs in and Around Orchards.—The Currant-borers and similar insects remain in the dead or dying canes until mature. By burning canes thus infected in early spring the culprits are killed. The New York-weevil, destructive to plum trees, breeds in oaks, chiefly in those twigs that drop very readily. By gathering and burning these at the proper time the insects are prevented from invading orchards.

Burning Dead Foliage, Etc.—Many insects, for instance the Chinch-bug, hibernate in and below such rubbish. By burning this material at a time when the insects are in a torpid condition they are destroyed. If this operation is carried out very late in autumn they are not very likely to find new hibernating quarters, or are thus exposed without any protection to the cold.

Permitting Hogs or Other Animals to Grub in Orchards, Windbreaks, and Tree Groves.—The large destructive Willow Saw-fly hibernates just under the surface of the soil, or even above it under rubbish. Their larvæ are readily detected and greedily eaten by hogs, skunks and shrews.

Concentrating Insects Upon Favorite Food Plants.—This can be done either by causing some plants in the outer rows to appear earlier than the rest, and thus concentrating upon them the great majority of the noxious insects, or by growing some rows of varieties preferred by them. In either case the insects thus concentrated upon a few plants can be much more readily killed than if scattered over a large field.

High Culture.—By manuring or by working the soil more thoroughly the plants grown upon it are stronger and more able to recover from damages caused by insects. Young plants of wheat, eaten down to the ground by young locusts, will recover and still produce a good crop if the land was in a prime condition.

Refraining for One or Two Years from Crops Badly Infested.—Chinch-bugs in our southern counties forced farmers to abandon the growing of wheat for a number of years. Lack of food, and other causes, destroyed the insects, and wheat can again be grown for some seasons. Rotation of crops has a similar, but not so thorough an effect upon insects.

Selection of Varieties Less Liable to Attack.—This is a very important natural remedy, and can be applied in many cases, but in other cases such unpalatable varieties are as yet unknown, and it is the office of the Experiment Station to make the necessary efforts to find them if they can be discovered. Diversified farming in infested regions is also very important as in this case it is never likely that all the crops will be destroyed, since nearly all insects are dependent for food upon certain plants, and neither can nor will eat others. Growing of unpalatable crops in place of others greedily eaten is also a similar natural remedy.

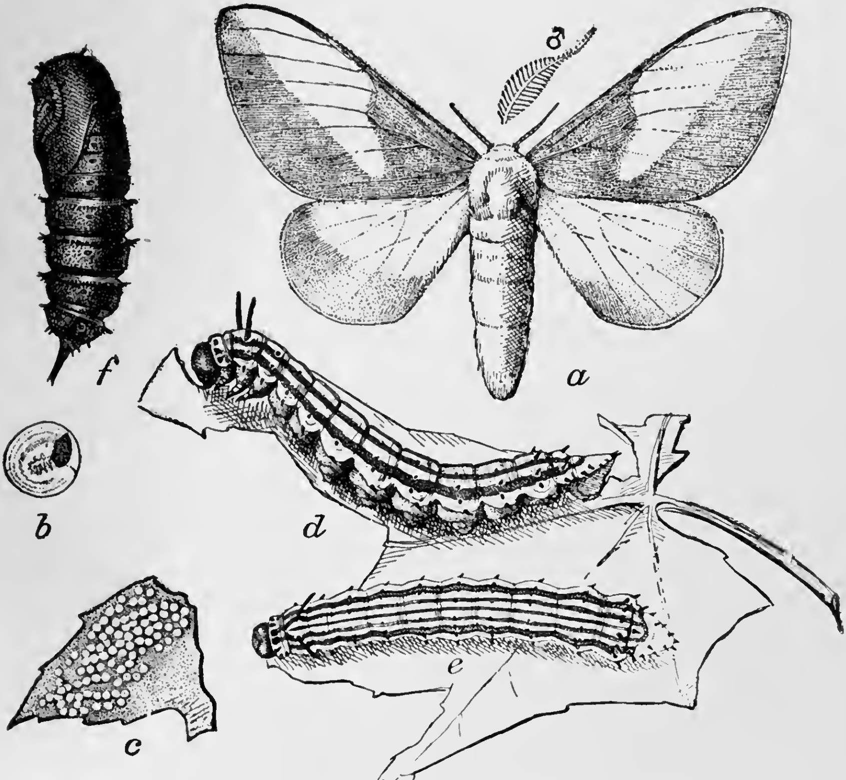
Late Sowing.—This is also an excellent method to prevent certain noxious insects from causing injury, and can be applied in many cases and to various crops. Late sowing of peas will prevent the Pea-weevil from depositing eggs upon such plants, because the weevils die before the plants are flowering. Keeping seed-peas longer than one year in a tight sack will have the same effect with most species.

Early Sowing.—This, if done properly, will enable the plants to attain such growth and strength as to be beyond serious injury.

Late Plowing; Early Plowing.—Both methods are sometimes of great value to protect crops grown upon fields thus treated. Late plowing will disturb and kill many insects that are hibernating in the soil. Tender insects and pupæ that can not move are thus killed. Early and repeated plowing will expose many insects otherwise hidden in the ground to the attacks of birds, shrews and other animals. The full-grown larvæ and pupæ of wire-worms are killed by disturbing the soil late in the fall. Young locusts can not reach the surface of the ground if the eggs are plowed under. Late plowing of

CLOVERHEAD SHOWING COCOON OF LESSER CLOVER LEAF WEEVIL. DEPT. OF AGR.

(See page 199.)



GREEN STRIPED MAPLE WORM (ANISOTA RUBICUNDA). DEPT. OF AGR.

fallow land is very important, as such fields attract many insects to deposit their eggs, or to hibernate in the undisturbed soil. Burning stubble at the proper time is also of great value in a number of cases. If the standing stubble, or a layer of dry straw, is burned at a time when young locusts are hatched the majority of them will be destroyed. Dry and dense masses of dead grass harbor many injurious insects, such as chinch-bugs, and should be burned. By burning the stubble we destroy also injurious insects that hibernate in the culms, such as the frit-fly.

Ditching.—To prevent such insects as young locusts, army-worms, migrating chinch-bugs and others from reaching fields as yet free from them, ditches prove of great value since the insects are gathered there and can be destroyed in immense quantities in various ways. When army-worms migrate they usually move all in the same direction. A ditch of sufficient depth will soon trap large numbers, and by means of burning straw, kerosene oil, or by dragging a log along the bottom of the ditch the insects can be destroyed.

Isolating Fields from Insects.—This can be done in various ways, depending upon the character of the insects to be kept away. To protect a corn field from chinch-bugs that migrate towards it from fields already devastated, a low fence made of a six-inch board, fastened by pins with its edge upon the ground, and having the expose edge covered with a fluid mixture of oil and tar, will prevent the bugs from crossing. Even a thick rope saturated from time to time with kerosene oil will prevent them from crossing this slight obstruction. The chinch-bugs, crowding together in front of this obstacle, can be killed in various ways, best by making holes in the ground with augers, and to close these as soon as filled with insects, and then to make others to take their place.

Inundating Fields.—Wherever this can be done farmers have almost complete control over a large number of kinds of noxious insects.

Mowing Crops Early.—This remedy can be applied in a number of cases and with very good effect. By mowing timothy badly infested with the lesser army-worm at a time when these caterpillars are still young, their food is destroyed and the great majority starve to death. Insects infesting the flowers of red clover can be combatted in a similar way. Other remedies consist of various devices to prevent destructive insects from reaching their food. Surrounding stems of young plants with paper or a piece of tin to keep away the cut-worms; tacking a strip of tin or tarred paper around trees to prevent the unwinged females of such moths as the canker-worm from ascending the trees to deposit their eggs, and other similar contrivances belong here.

Introducing Diseases.—This among injurious insects is receiving now a great deal of attention, and many trials have been more or less successful; yet very much remains to be done in this line of experimentation.

Protecting Beneficial Mammals, Birds and Reptiles.—This is one of the best natural remedies we have. It is sad to watch the gradual disappearance of so many of our feathered friends, and the ignorance prevailing in regard to other animals, which are hunted down and killed without mercy, although many of them are our friends. The relation between our wild animals and agriculture has not received that attention which it well deserves. Many animals are considered the greatest enemies of man while in fact they are his benefactors and deserve corresponding treatment.

Many other methods might be enumerated by means of which we can counteract the undue increase of noxious insects, but the above list is sufficient to show that even without the use of poison and machinery much can be done to protect our crops. But we must always study the habits of our enemies, and thus become enabled to select just the one remedy that promises to be effectual. In the warfare against noxious insects thêre is no royal road which can always be followed.

Introduction of Parasites and Cannibal Insects.—This is also a very promising remedy in some few and special cases. In a state of nature the relationship between plants and insects is so nicely balanced that each species has a number of checks which prevent undue increase. But even there it sometimes happens that such checks become ineffectual from disease or unfavorable climatic conditions, and as a consequence devastations upon a large scale take place. But as a very general rule the disturbed balance is soon restored to its equilibrium. When man imagines he can improve upon nature by adding, purposely or otherwise, a new factor, or by removing one, most unexpected results may follow. For instance the introduction of the European rabbit into Australia was followed by such deep-rooted disturbances between animals and plants that the whole Australian nation is now forced to fight this animal to regain possession of the agricultural products. The introduction of the English sparrow into the United States is another example, and has already been of sufficient influence to disturb the ancient order of things. So it is with the accidental introduction of foreign noxious insects, as our farmers have learned to their sorrow. As such recently introduced species are usually not accompanied by their enemies these latter ought to be introduced after careful consideration of the case in all its bearings.

To the natural methods to prevent the undue increase of noxious insects might be added proper *laws*. People unwilling to do their share in preventing losses caused by insects ought to be forced by carefully prepared laws to do their duty, if not to themselves, at least to their neighbors and to the community at large. Insects that threaten to become a serious danger to the inhabitants of a whole state should be considered as a public calamity, like some contagious disease, and should be suppressed by every known means.—(Bul. 28, Minn. Agr. Exp. Sta.)

Barriers.—Many plants may be protected at critical periods by surrounding them by some obstacle which the threatening insect cannot pass. Frames or boxes without tops or bottoms, covered with mosquito netting above, are extensively used in some sections to protect the hills of young melon or cucumber vines from the attack of the striped cucumber beetle. Such a frame can be made by sawing a barrel hoop in two, tacking the two halves together at their centers at right angles to each other, and covering with the netting.

Barriers to prevent the migration of the chinch-bug from the ripening small grains to the corn afford frequently the best means of protecting the latter during a chinch-bug invasion. One of the most successful of these is the tar barrier. This is made by smoothing a strip of ground along the side of the corn field next to the small grain by drawing a well weighted float or stone-boat up and down until a smooth surface is obtained. Two narrow lines of coal tar are then poured along this strip at such a distance apart that the float may be readily drawn between them. The tar may best be poured from a watering pot with a small spout, from which the rose has been removed. Holes similar to post holes are then dug at frequent intervals, close up to the outside of the line of tar toward the small grain. The migrating chinch-bugs, reaching the first line of tar, will turn aside and march parallel to it, tumbling into the holes. It will be seen that there must not be the slightest interval between the edge of the hole and the tar line, as in that case the bugs would crawl between them. As fast as the holes are filled the bugs may be destroyed by throwing a little kerosene upon them, and then dug out to give place to others. If the bugs are very numerous, they will at places crowd over the first line of tar, forming bridges of their own bodies so that free passage is made for those coming behind. Frequent examination is therefore necessary and the repairing of any such breaks. The bugs that get in between the two lines in this way may be crushed by drawing the float along between the two lines.

To prevent larvæ and wingless adult insects from climbing the trunks of trees various forms of barriers have been devised. A strip of paper composed of several thicknesses and tied around the tree with a piece of string near its upper edge or at its middle so that the lower edge projects from the tree at all points, is sufficient in some cases and is the simplest form when it will serve the purpose. Painting a band around the trunk with some sticky substance is also a common method. Besides these simple means, there are a number of patented appliances on the market that serve the purpose excellently where the expense is not sufficient to prevent their use. The tree bands are used mostly to keep off the trees migratory larvæ and to prevent the wingless females of the canker worm from ascending the trees to lay their eggs.

Trunk Washes.—To prevent the deposition of the eggs of various wood borers various repellant substances are applied to the trunks of the trees. One of the best of these is made by mixing hydraulic cement with skimmed milk until it is of as thick a consistency as can be readily applied with a whitewash brush. The trunk of the tree is thoroughly painted with this before the egg laying season of the insect feared. One application will suffice for the season. This is most extensively used for the peach borer, but can be applied for other forms.

Worming.—In case of most wood boring insects, digging the larvæ out with a knife is a method largely followed, and indeed the one chiefly depended upon in many districts, where the worming of the peach and other trees is as regular a part of the year's work as plowing or cultivating. The forcing of a flexible wire into the burrow injures the bark less and in skillful hands may be quite effective.

Hopper Dozers.—For the destruction of young grasshoppers, one of the most effective means is the use of shallow pans, made usually of sheet iron, the bottom covered with kerosene or coal tar, which are drawn over the ground by horses so that the insects in trying to escape will leap into the pans. At the rear of the pan is a vertical screen to prevent their leaping entirely over. The pans are supported on low runners so that they slide easily over the ground. Such an apparatus is called a hopper dozer. We believe that in many cases its use would pay for the destruction of other insects than grasshoppers, especially in pasture lands that are badly infested with small leaf hoppers.—(Bul. 50, Iowa Agr. Exp. Sta.)

CONTROL BY LEGISLATION.

Most states have laws on the statutes governing the inspection, sale and importation of nursery stock and some states have laws governing the sale of scale infested fruit. Under these laws the nurseries are inspected for injurious insects and plant diseases and the stock required to be fumigated before sale. To nurseries found to be apparently free from pests a certificate is issued which must be attached to the stock sold. In this way a great deal is done towards insuring the farmer against the introduction of pests on his premises.—(Cir. 75, Sec. Rev. U. S. D. A. B. E.)

IMPORTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

These are not covered by patents, and in general it is true that the patented articles are inferior, many of the better of them being in fact merely more or less close imitations of the standard substances and compounds hereinafter described. Only such brief references to food and other habits of insects will be included as are necessary to illustrate the principles underlying the use of the several insecticide agents.

Relation of Food Habits to Remedies.—For the intelligent and practical employment of insecticides it is necessary to comprehend the nature and method of injury commonly due to insects. Omitting for the present purpose the exceptional forms of injury which necessitate peculiar methods of treatment, the great mass of the harm to growing plants from the attacks of insects falls under two principal heads based on distinct principles of food economy, viz., whether the insect is a biting or a sucking species. Each group involves a special system of treatment.

Injury from Biting Insects.—The biting or gnawing insects are those which actually masticate and swallow some portion of the solid substance of the plant, as the wood, bark, leaves, flowers, or fruit. They include the majority of the injurious larvæ, many beetles, and the grasshoppers.

For these insects direct poisons, such as the arsenicals, which may be safely applied to the leaves or other parts of the plant attacked, and which will be swallowed by the insect with its food, furnish the surest and simplest remedy, and should always be employed, except where the parts treated are themselves to be shortly used for the food of animals or of man.

Injury from Sucking Insects.—The sucking insects are those which injure plants by the gradual extraction of the juices from the bark, leaves, or fruit, and include the plant-bugs, aphides, scale insects, thrips, and plant-feeding mites. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark or leaves into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious.

For this class of insects the application of poisons, which penetrate little, if at all, into the plant cells, is of trifling value, and it is necessary to use substances which will act externally on the bodies of these insects as a caustic, or will smother or stifle them by closing their breathing pores, or will fill the air about them with poisonous fumes. Of value also as repellents are various deterrent or obnoxious substances. Where it is not desirable to use poisons for biting insects some of the means just enumerated may often be employed.

Groups Subject to Special Treatment.—The two general groups outlined above comprise the species which live and feed upon the exterior of plants for some portion or all of their lives, and include the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these, two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root maggots, root aphides, etc.; and (2) insects affecting stored products, as various grain and flour pests.

The classification of insects outlined above, based on mode of nourishment, and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

- I. External feeders:
  - (*a*) Biting insects.
  - (*b*) Sucking insects.
- II. Internal feeders.
- III. Subterranean insects.
- IV. Insects affecting stored products.
- V. Household pests.
- VI. Animal parasites.

THE ARSENICALS.

Paris Green.—Paris green is a definite chemical compound of white arsenic, copper oxide, and acetic acid, and is known as the aceto-arsenite of copper. Properly compounded and washed, it should be substantially uniform in composition and nearly free from uncombined soluble white arsenic. It is a rather coarse powder, or, more properly speaking, crystal, and settles rapidly in water, which is its greatest fault. To give better suspension in water, it should be reduced to such fineness by grinding that it will pass through a 100-mesh sieve. Its high cost (varying from 20 to 40 cents a pound, following the market price of copper and arsenic) is further increased by its being crystallized with acetic acid, making it a more brilliant pigment, but giving it a coarse grain and rendering it a poorer insecticide. The standards of purity demanded by various States have led most manufacturers to produce a very fair article, but if there is any doubt of purity a sample should be submitted to the State Experiment Station or to the United States Department of Agriculture for analysis.

Hellebore.—The powdered roots of the white hellebore (*Veratrum viride*) are often recommended and used as an insecticide, particularly as a substitute for the arsenites. This substance is useful when a few plants only are to be sprayed, as in yards and small gardens, but is too expensive for large operations. It kills insects in the same way as the arsenicals, as an internal poison, and is less dangerous to man and the higher animals; but if a sufficient amount be taken it will cause death. It is particularly effective against the larvæ of sawflies, such as the cherry slug, rose slug, currant worms, and strawberry worms. It may be applied as a dry powder, preferably diluted with from 5 to 10 parts of flour, and dusted on the plants through a muslin bag or with powder bellows. The application should be made in the morning, when the plants are moist with dew. Used as a wet application, it should be mixed with water in the proportion of 1 ounce to the gallon of water and applied as a spray.

Arsenite of Lime.—This is normally a home-made preparation, and there is no reason for its not being employed wherever one is willing to take the trouble to compound it carefully. Its preparation, described below, following substantially the Kedzie formula, is simple enough:

White arsenic	pounds..	1
Crystal sal soda*	do...	4
Water	gallons..	1

Place the above ingredients in an iron vessel, which is to be kept exclusively for this purpose, and boil for twenty minutes or until dissolved. To 40 or 50 gallons of water a pint of this stock solution and 3 to 4 pounds of freshly slaked lime are added. This excess of lime not only takes up any free arsenic, but by its distribution on the foliage enables one to determine how well the spraying has been done. This formula has been thoroughly tested and used now for many years, and is fully as efficient as any other arsenical and far cheaper. Chemically it is arsenite of lime. The soda is used to hasten the process and to insure the combination of all the arsenic with the lime. The greatest care should be exercised in preparing the stock mixture, and afterwards it should be plainly labeled to prevent its being mistaken for some other substance. The only objec-

*Two pounds only of the *anhydrous* sal soda are necessary.

tion to its use is the necessity of handling the poisons in its home preparation.

Arsenate of Lead.—Arsenate of lead may be prepared at home by combining approximately 3 parts of crystallized arsenate of soda with 7 parts of crystallized acetate of lead (sugar of lead) in water. This gives a slight excess of acetate of lead. Each of the ingredients should be dissolved separately in water in wooden vessels, and the two solutions poured together into the spray tank filled with water. The white, flocculent precipitate of arsenate of lead which immediately results is extremely fine and remains in suspension much longer than any other arsenical. Furthermore, prepared in this way and diluted at once, there is secured a mixture that is chemically superior to the combined product sold in paste form and that remains in suspension better. Arsenate of soda costs wholesale about 10 cents a pound, and first-class acetate of lead about 10 cents a pound.

Arsenate of lead may be used at any strength from 3 to 15 pounds to 100 gallons of water without injury to the foliage, for the reason that it contains little, if any, soluble arsenic. It is ordinarily used at the rate of 4 to 6 pounds to the 100 gallons of water or Bordeaux mixture. In later years it has come into general use especially for spraying plants sensitive to arsenical poisoning, such as peach, and also in cases where it is necessary to make heavy applications. Its safety as regards the burning of foliage and its adhesive quality offset its greater cost, and it is now much used in the codling moth work and general arsenical spraying.

In the home preparation of this arsenical, the number of pounds of the poison per 100 gallons of water as given in directions for use should be understood to mean the combined weights of the two ingredients. In point of fact, the resulting lead arsenate is only about half the actual weight of the two ingredients, which explains in part the apparently excessive amounts used as compared with other arsenicals.

A good many brands of arsenate of lead can be purchased on the market, usually in the form of heavy pastes. As already indicated, they have not the same power of remaining in suspension as the freshly made product, but are otherwise, if properly made, quite satisfactory. The water content, which is variable, should be specifically indicated and guaranteed, to make it possible to use the poison at the strength desired. Arsenite of lead is a compound very similar to the arsenate of lead, but it contains a less percentage of arsenic. It is prepared from sodium arsenite.

General Consideration.—In point of solubility and corresponding danger of scalding the foliage, these arsenicals fall in the following order, the least soluble first: Arsenate of lead, arsenite of lime, Paris green, copper arsenite, and London purple. In point of cost the arsenite of lime is much cheaper than the other arsenicals, and the arsenate of lead, at the rate at which it is necessary to use it, much the most expensive. But after all the main cost is in the application, and it is therefore well worth while to secure a good arsenical and get the best results.

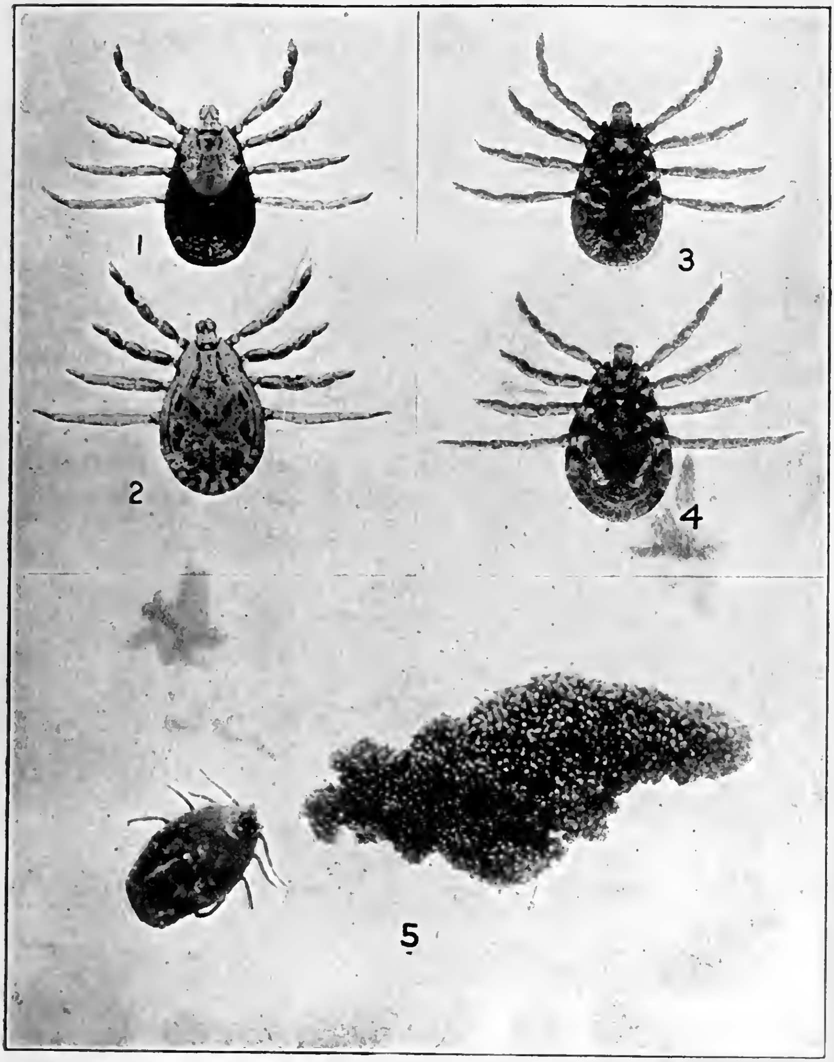
HOW TO APPLY ARSENICALS.

There are three principal methods of applying arsenicals. The wet method, which consists in using these poisons in water in the form of spray, is the standard means, secures uniform results at least expense, and is the only practical method of protecting fruit and shade trees. The dry application of these poisons in the form of a powder, which is dusted over plants, is more popular as a means against the cotton worm in the South, where the rapidity of treatment possible by this method, and its cheapness, give it a value against this insect, in the practical treatment of which prompt and economical action are the essentials. This method is also feasible for any low-growing crop, such as potatoes, young cabbages, or other plants not to be immediately employed as food. The third method consists in the use of the arsenicals in the form of poisoned baits, and is particularly available for such insects as cutworms, wireworms, and grasshoppers in local invasions.

The Wet Method.—Either Paris green, arsenite of copper, arsenite of lime, or London purple may be used at the rate of 1 pound of the poison to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The stronger mixtures are for such vigorous foliage as that of the potato, and the greater dilutions for the more tender foliage of the peach or plum. An average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should first be made into a thin paste in a small quantity of water and quicklime added in amount equal to the poison used, to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees paris green may be applied without danger at the strength of 1 pound to 150 gallons of water; with London purple it is always better to use the lime. The method of preparation of arsenate of lead has already been indicated. Lime is not needed with this arsenical.

If it be desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic and makes it an excellent medium for the arsenical, as it removes liability of scalding the foliage and permits an application of the arsenical, if necessary, eight or ten times as strong as it could be employed with water alone.

The arsenicals can not be safely used with most other fungicides, such as the sulphate of copper, eau celeste, or iron chloride solution, the scalding effects of these being greatly intensified in the mixture.



ROCKY MOUNTAIN SPOTTED-FEVER TICK
1. FEMALE; 2. MALE; 3. FEMALE; 4. MALE; 5. FEMALE DEPOSITING EGGS.
DEPT. OF AGR.

The Dry Method.—The following description applies to the pole-and-bag duster commonly used against the cotton worm: A pole 5 to 8 feet long and about 2 inches in diameter is taken, and a three-fourths-inch hole bored through it within 6 inches of each end. Near each end is securely tacked a bag of "8-ounce osnaburg cloth," 1 foot wide and 18 inches to 2 feet long, so that the powdered poison may be introduced into the bags with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried on horse or mule back, through the cotton fields, dusting two or four rows at once. The shaking induced by the motion of the animal going at a brisk walk or at a trot is sufficient to dust the plants thoroughly, or the pole may be jarred by hand. The application is preferably made in early morning or late evening, when the dew is on, to cause the poison to adhere better to the foliage.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains may necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery. The cost frequently does not exceed 25 cents per acre, and the results are so satisfactory that the leaf worm is no longer considered a serious factor in cotton culture.

With the patented air-blast machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres may be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from $30 to $60) prevents their general use. The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this or similar means from bags or with hand bellows, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime, and for application to vegetables which ultimately will be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or 10 of lime and dusted merely enough to show evenly over the surface. Arsenicals should not be applied to lettuce or other vegetables the free leafage of which is eaten.

Poisoned Bait.—It is not always advisable or effective to apply arsenicals directly to the plants, and this is particularly true in relation to the attacks of the grasshopper and of the various cutworms and wireworms. In such cases the use of poisoned bait has proved very satisfactory.

For grasshoppers, take 1 part, by weight, or white arsenic, 1 of sugar, or molasses, and 6 of bran, to which add water to make a wet mash. Place a tablespoonful of this at the base of each tree or vine, or apply a line of baits just ahead of the advancing army of grasshoppers, placing a tablespoonful of the mash every 6 or 8 feet and following up with another line behind the first.

A cheap grasshopper bait used successfully in parts of the West is obtained by mixing fresh horse droppings with arsenicals. One pound of Paris green, or some other convenient arsenical, together with 2 pounds of salt, are thoroughly mixed with 60 pounds of fresh horse droppings. The resulting mixture is scattered among the young hoppers or around the edges of fields which it is thought may be invaded. A very convenient receptacle in which to make this preparation is a half barrel. A trowel or paddle can be used in scattering the mixture in the desired places.

Bran and Paris green, on the authority of Prof. J. B. Smith, thoroughly mixed and sprinkled dry on cabbage heads, proved a most successful remedy for cabbage worms, the latter preferring the poisoned bran to the cabbage, to their prompt undoing. The same dry mixture has been successfully employed against cutworms and is recommended by Smith for the army worm, running it in rows 10 feet apart across the infested field. One pound of poison to 10 of bran is a good proportion. The bran-arsenic bait may also be used for cutworms.

For sowbugs, or pillbugs, which frequently are injurious pests to tender flowering plants and vegetables grown under frames or in glass houses, poisoned slices of potato have proved to be the most effectual remedy. The freshly sliced potato may be poisoned by dipping in a strong arsenical solution, or by dusting thickly with a dry arsenical, and should then be distributed over the beds. Pansy beds have been notably protected in this way, and a Michigan vegetable grower reports that in two nights he destroyed upward of 24,000 of these bugs by this means in four houses used for lettuce growing.

Another remedy for cutworms and also for wireworms is poisoned green succulent vegetation, such as freshly cut clover, distributed in small bunches in the infested fields. Dip the bait in a very strong arsenical solution, and protect it from drying by covering. Renew the bait as often as it becomes dry, or every three to five days.

Care in the Use of Arsenicals.—It must be remembered that these arsenicals are very poisonous and should be so labeled. If ordinary precautions are taken, there is no danger to man or team attending their application. The wetting of either, which can not always be avoided, is not at all dangerous, on account of the great dilution of the mixture, and no ill effects whatever have resulted from this source. With some individuals the arsenate of lead, when in strong mixture, affects the eyes, but this is unusual, and, with a little care in spraying, the mist need not strike the operator at all.

The poison disappears from the plants almost completely within twenty to twenty-five days, and even if the plants were consumed shortly after the application, an impossible quantity would have to be eaten to get a poisonous dose. To illustrate, in the case of the apple, if the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose, and with the cabbage, dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result. It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

The simple remedies for this class of insects, such as soap, insect powder, sulphur, tobacco decoction, etc., are frequently of value, but need little special explanation. Some brief notes will be given, however, describing the methods of using some of these substances which are easily available and will often be of service, particularly where few plants are to be treated. The standard remedies for this group of insects, viz., crude petroleum, kerosene, and kerosene emulsions, resin washes, lime-sulphur wash, hydrocyanic acid gas, and vapor of bisulphid of carbon, will be treated farther on.

Soaps as Insecticides.—Any good soap is effective in destroying soft-bodied insects, such as aphides and young or soft-bodied larvæ. As winter washes in very strong solution, they furnish one of the safest and most effective means against scale insects. The soaps made of fish oil and sold under the name of whale-oil soaps are often especially valuable, but they are variable in composition and merits. A soap made with caustic potash rather than with caustic soda which is commonly used, and not containing more than 30 per cent of water, should be demanded, the potash soap yielding a liquid in dilution more readily sprayed and more effective against insects. The soda soap washes are apt to be gelatinous when cold, and difficult or impossible to spray except when kept at a very high temperature.

For aphides and delicate larvæ, such as the pear slug, a strength obtained by dissolving half a pound of soap in a gallon of water is sufficient. For the pea aphis as little as 1 pound of potash fish-oil soap to 6 gallons has been effective. Soft soap will answer as well as hard, but at least double quantity should be taken.

As a winter wash for the San Jose and allied scale insects, whale-oil or fish-oil soap is dissolved in water by boiling at the rate of 2 pounds of soap to the gallon of water. If applied hot and on a comparatively warm day in winter, it can be easily put on trees with an ordinary spray pump. On a very cold day, or with a cold solution, the mixture will clog the pump and difficulty will be experienced in getting it on the trees. Trees should be thoroughly coated with this soap wash. Pear and apple trees may be sprayed at any time during the winter. Peach and plum trees are best sprayed in the spring, shortly before the buds swell. If sprayed in midwinter or earlier, the soap solution seems to prevent the development of the fruit buds, and a loss of fruit for one year is apt to be experienced, the trees leafing out and growing, however, perhaps more vigorously on this account. The soap treatment is perfectly safe for all kinds of trees, and is very effective against the scale. With large trees, or badly infested trees, as a preliminary treatment, it is desirable with this as well as other applications to prune them back very rigorously. This results in an economy of spray and makes much more thorough and effective work possible. The soap can be secured in large quantities at from 3½ cents to 4 cents a pound, making the mixture cost, as applied to the trees, from 7 cents to 8 cents a gallon.

Soap Washes.—The most effective soap wash is made with whale-oil soap, one pound to from four to six gallons of water. The term whale-oil soap is merely a trade name for fish-oil soap, made with either potash or soda. The potash soaps, which are the best, because even stronger solutions remain liquid when they cool, are soft soaps. The soda soaps are hard. Of the two, the potash soaps are considered the best to use on vegetation, as well as being more convenient. Both kinds should always be dissolved in hot water.

When bought at retail prices, these soaps cost from 15 to 20 cents per pound, according to the locality, but if obtained in large quantities, can be got at from 3 to 5 cents per pound. Fifty-pound kegs are supplied at 5 cents per pound. Two well-known brands of potash soft soaps which have been much used in Canada, and have given good satisfaction, are those made by W. H. Owen, of Port Clinton, Ohio, and by Good & Co., of Philadelphia, Pa. If thought desirable, these soaps can be made at home; but it is very unpleasant and dirty work, and it is, besides, doubtful whether such good or cheap results can be secured as by buying from firms which make a special business of manufacturing soaps with only the required amount of moisture and the proper grade and amount of potash. It has been found in experiments carried on at Washington that what is required for spraying purposes is a caustic potash and fish-oil soap, made with a fairly good quality of fish-oil, and from which water has been eliminated by boiling, so that it does not exceed 25 or 30 per cent of the weight of the soap. Soaps made with caustic soda instead of caustic potash are unsuitable for spraying purposes. Dr. J. B. Smith (New Jersey Experiment Station), in his circular No. 5, "Whale Oil Soap and Its Uses," says that whale-oil, or fish-oil, soap is one of the most reliable materials for use against plant-lice, and generally against sucking insects which can be killed by contact insecticides. It kills by clogging the spiracles, or breathing pores, of the insects, and also to some extent by its corrosive action. The advantages of fish-oil over ordinary laundry soap lie in the greater penetrating power, in the fact that it remains liquid when cold, at much greater strengths, and that fish-oil itself seems to be more fatal to insect life than other animal fats. A good soap can be made as follows:

Concentrated potash lye	3½	pounds.
Water	7½	gallons.
Fish-oil	1	gallon.

Dissolve the lye in water, boil, and to the boiling solution add the fish-oil; continue to boil for two hours, and then allow to cool. Any grade of fish-oil will answer. Whale-oil soap may be applied in the strength of one pound in four gallons of water for brown or black plant-lice, and one pound in six gallons for green plant-lice; warm water should always be used when dissolving it. Soaps of all kinds are very useful in adding adhesiveness to liquid mixtures when it is necessary to apply these to such vegetation as cabbages, turnips, peas, etc., which have their leaves covered with a waxy secretion which prevents water from lying upon them. Any kind of soap will answer for this purpose, and it may be remembered that one quart of soft soap is about equal to one pound of hard soap. Another method for making home-made fish-oil soap is given by Van Slyke and Urner, and is as follows:

Formula for Making Forty Pounds of Fish-Oil Soap.

Caustic soda	6	pounds.
Water	1½	gallons.
Fish-oil	22	pounds.

The caustic soda is completely dissolved in the given amount of water and the fish-oil is added gradually under constant and vigorous stirring. The combination occurs readily at ordinary summer temperatures and the operation is soon completed. The mixing may be done in any receptacle sufficiently large to contain the whole amount of material. It would probably not be desirable to attempt to make more than 20 to 40 pounds at a time, since the difficulty of thoroughly stirring a larger mass would tend to make a complete combination less sure, thus rendering liable the presence of too much free alkali. *Complete and thorough stirring is essential to success.* Caustic soda should be handled with precaution, since in concentrated form it easily injures the skin. The authors show that when caustic soda can be got for 4½ cents per pound and the fish-oil at 29 cents per gallon, the material for 40 pounds of soap costs $1.14, or 2.85 cents per pound.—(Bul. 154, Ontario Agr. Dep.)

Pyrethrum, or Insect Powder.—This insecticide is sold under the names of Buhach, Dalmatian, and Persian insect powder, or simply insect powder, and is the ground-up flowers of the Pyrethrum plant. It acts on insects externally through their breathing pores, and is fatal to many forms both of biting and sucking insects. It is not poisonous to man or the higher animals, and hence may be used where poisons would be objectionable. Its chief value is against household pests, such as roaches, flies, and ants, and in greenhouses, conservatories, and small gardens, where the use of arsenical poisons would be inadvisable.

It is used as a dry powder, pure or mixed with flour, in which form it may be puffed about rooms or over plants. On the latter it is preferably applied in the evening, so as to be retained by the dew. To keep out mosquitoes, and also to kill them, burning the powder in a tent or room will give satisfactory results.

It may also be used as a spray at the rate of 1 ounce to 2 gallons of water, but in this case should be mixed some twenty-four hours before being applied. For immediate use, a decoction may be prepared by boiling in water from five to ten minutes.

Tobacco Decoction.—A tobacco decoction sufficiently strong for aphides and other very delicate insects may be prepared from tobacco stems and other refuse tobacco by boiling at the rate of 1 pound for each 1 or 2 gallons of water, sufficient water being added to make up for that lost in boiling.

Sulphur.—Flowers of sulphur is one of the best remedies for plant mites, such as the red spider, the six-spotted orange mite, and the rust mite of citrus fruits. It may be applied in several forms, the simplest of which is its use as a dry powder dusted over the trees with powder bellows or any broadcasting device, preferably in the early morning when the foliage is damp with dew, or immediately after a rain. For the rust mite in very moist climates, such as that of Florida, to keep the fruit bright it is sufficient merely to sprinkle the sulphur about under the trees. The flowers of sulphur may be easily applied also with any other insecticide, such as kerosene emulsion, resin wash, or a soap wash, mixing it up first into a paste and then adding it to the spray tank at a rate of from 1 to 2 pounds to 50 gallons. Somewhat more uniform results can be obtained perhaps by getting the sulphur into solution, either dissolving it with lye or by boiling it with lime.—(Farmers' Bul. 127, U. S. Dep. of Agr.)

In making the lye-sulphur wash, first mix 20 pounds of flowers of sulphur into a paste with cold water, then add 10 pounds of pulverized caustic soda (98 per cent). The dissolving lye will boil and liquefy the sulphur. Water must be added from time to time to prevent burning, until a concentrated solution of 20 gallons is obtained. Two gallons of this is sufficient for 50 gallons of spray, giving a strength of 2 pounds of sulphur and 1 of lye to 50 gallons of water. An even stronger application can be made without danger to the foliage. This mixture can also be used in combination with other insecticides.

The chemical combination of sulphur and lime known as sulphid of lime is perhaps a better liquid sulphur solution than the last as a remedy for mites. It may be very cheaply prepared by boiling together for an hour or more, in a small quantity of water, equal parts of flowers of sulphur and stone lime. A convenient quantity is prepared by taking 5 pounds of sulphur and 5 of lime and boiling in 3 or 4 gallons of water until the ingredients combine, forming a brownish liquid. This may be diluted to make 100 gallons of spray.

Almost any of the insecticides with which the sulphur may be applied will kill the leaf of rust mites, but the advantage of the sulphur arises from the fact that it forms an adhering coating on the leaves and kills the young mites coming from the eggs, which are very resistant to the action of insecticides.

Petroleum Oils.—The emulsions of kerosene, or coal oil, with soap or milk have long been the standard insecticides for external sucking insects, and especially the aphides and scale insects, and these emulsions still are the safest and most reliable means of getting these oils upon plants.

In addition to its direct application to plants, kerosene is often used as a means of destroying insects by jarring the latter from plants into pans of water on which a little of the oil is floating, or by jarring them upon cloths or screens saturated with kerosene, preferably the crude oil. The same principle is illustrated in some of the hopper-dozers, or machines for collecting grasshoppers and leaf-hoppers.

As a remedy for mosquitoes, kerosene has proved very effective. It is employed to destroy the larvæ of the mosquitoes in their favorite breeding places in small pools, still ponds, or stagnant water; and where such bodies of water are not sources of drinking supply or of value for their fish, especially in the case of temporary pools from rains, which frequently breed very disagreeable local swarms, the use of oil is strongly recommended. The kerosene is applied at the rate of 1 ounce to 15 square feet of water surface. It forms a uniform film over the surface and destroys all forms of aquatic insect life, including the larvæ of the mosquito, and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains. A light grade of fuel oil is preferred for this purpose. The methods of using kerosene as emulsions with soap and milk follow.

Kerosene Emulsion (*soap formula.*)—The kerosene-soap emulsion, following chiefly the Riley-Hubbard formula, has been one of the standard means against scale insects for twenty years. The distillate emulsion generally employed in California for spraying citrus and other trees is substantially the same thing, except that it is made with the California distillate or petroleum oil. Crude petroleum of any kind, as well as the refined product, may also be used in making this emulsion. Emulsions may be applied at any strength with absolute confidence that there will be no variation. Where the emulsion can be prepared wholesale by steam power, its employment is attended with no difficulties. In California it is prepared by oil companies and sold at very slightly more than the cost of the oil and soap ingredients. It is made after the following formula:

Petroleum	gallons..	2
Whale-oil soap (or 1 quart soft soap)	pound..	½
Water (soft)	gallon..	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the oil. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assume the consistency of cream. Well made, the emulsion will keep indefinitely and should be diluted only as wanted for use.

In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water, and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water should be employed.

Kerosene Emulsion (*milk formula*).—This formula is as follows:

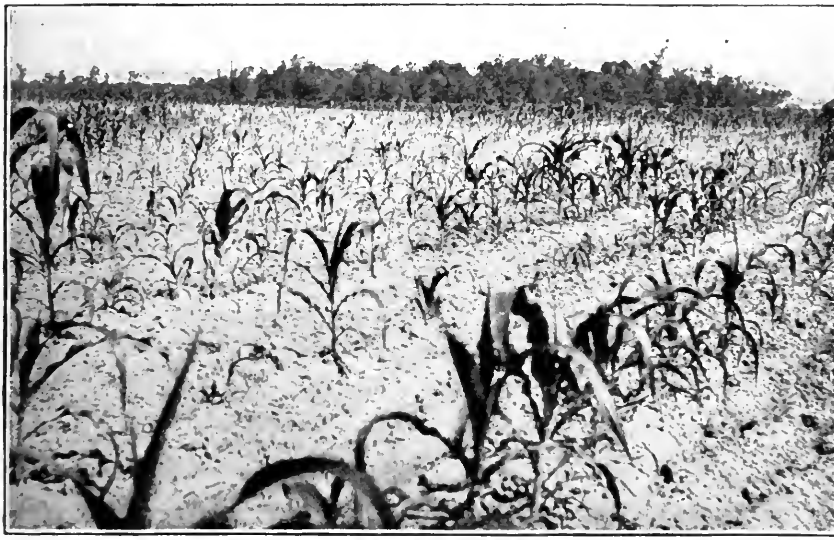
Kerosene	gallons..	2
Milk (sour)	gallon..	1

Heating is unnecessary in making the milk emulsion, which otherwise is churned as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use, unless it can be stored in quantity in air-tight jars; otherwise it will ferment and spoil after a week or two.

The Distillate Emulsion.—This wash was originated by Mr. F. Kahles, of Santa Barbara, Cal. It has been recommended by the California State Board of Horticulture and has found very general use in the citrus sections of the State. It is substantially an emulsion of crude petroleum, made in the same way as the kerosene emulsion described above, except that a greater amount of soap and only half as much oil proportionately is used. The lessened quantity of oil enables it to be made comparatively cheaply, and in spite of this reduction in the oil, the wash is, if anything, stronger than kerosene emulsion, judging from the experience of the writer with both these washes in southern California.

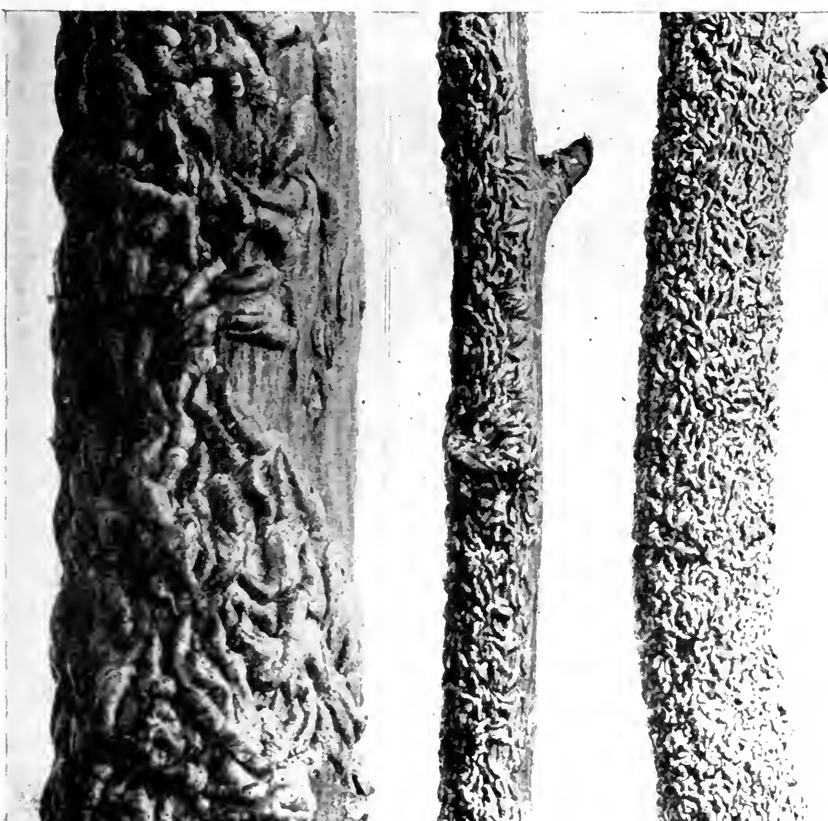
It is termed distillate spray, because the oil used is a crude distillate of the heavy California petroleum. The product used for preparing the emulsion should have a gravity of about 28° Baume, and is the crude oil minus the lighter oil, or what distills over at a temperature between 250° and 350° C. In general characteristics it is very similar to lubricating oil. The emulsion, or, as it is generally known, cream, is prepared as follows: Five gallons of 28° gravity distillate; 5 gallons of water, boiling; 1 to 1½ pounds of whale-oil soap. The soap is dissolved in hot water, the distillate added, and the whole thoroughly emulsified by means of a power pump until a rather heavy yellowish, creamy emulsion is produced. The product is very similar to, but rather darker in color than the ordinary kerosene emulsion. For use on citrus trees it is diluted with from 12 to 15 parts of water, the stronger wash for the lemon and the weaker for the orange. The distillate cream is commonly prepared and sold by oil companies or individuals at from 10 to 12 cents a gallon, making the diluted mixture cost in the neighborhood of a cent a gallon.

The distillate spray has the same range of application as kerosene emulsion. In California it has been used extensively for the spraying of citrus trees and when so used has been often charged with injury to trees, and especially resulting in spotting of fruit. If this spray be applied to citrus plants in spring and summer, there is danger of the spotting and dropping of the young fruit and leaves. Where several applications may be necessary each year, gas fumigation is undoubtedly preferable. Nevertheless it has been demonstrated that any applications made to citrus trees during the comparatively dormant season in October and November, with a second



Corn in Indiana Damaged by Corn Root-Aphis. (Aphis Maidi Radicis.)
Dept. of Agr.

(See page 169.)



Oyster Shell Scale. (Lepidosaphes Ulmi.) D[illegible] A[illegible]

(See pages 33 an[illegible])

treatment if necessary in January and February, the latter just before the flower spurs start, results in no injury.

How to Use the Emulsions.—During the growing period of summer, for most aphides and other soft-bodied insects, dilute the emulsion with 15 parts of water; for the red spider and other plant-mites, the same, with the addition of 1 ounce of flowers of sulphur to the gallon; for scale insects, the larger plant-bugs, larvæ, and beetles, dilute with from 7 to 10 parts of water. Apply with spray pump. The greatest dilution noted gives 4 per cent of oil and the lesser dilutions approximately 6 and 8 per cent.

For winter applications to the trunks and limbs of trees in the dormant and leafless condition to destroy scale insects, stronger mixtures may be used, even to the pure emulsion, which can not be sprayed successfully but may be applied with brush or sponge. Diluted with one or more parts of water it may be applied in spray without difficulty. The use of the pure emulsion is heroic treatment and only advisable in cases of excessive infestation.

The winter strengths recommended are the emulsion diluted with either 3, 4, or 5 parts of water, giving approximately 17, 13, and 11 per cent of oil. These dilutions are equivalent in strength to oil-water sprays containing 25, 20, and 15 per cent of oil, because relatively more of the emulsion is held by the bark. The two stronger mixtures may be used on the apple and pear and the weaker one on peach and plum. The winter treatment may be followed in June by a use of the summer wash to destroy any young which may come from female scales escaping the stronger mixture.

Cautions Regarding Use of Oil Washes.—In the use of kerosene washes, and, in fact, of all oily washes on plants, the application should be just sufficient to wet the plant without allowing the liquid to run down the trunk and collect about the root. Usually, in the case of young trees at least, there is a cavity formed by the swaying of the tree in the wind, and accumulation of the insecticide at this point, unless precautions be taken, may result in the death or injury of the plant. Under these conditions it may be advisable to mound up the trees before spraying and firmly pack the earth about the bases. Care should be taken in refilling the tank that no free oil is allowed to accumulate gradually in the residue left at the bottom when spraying with emulsions or oil-water mixtures.

Miscible Oils.—It will be noted that the difficulty to be overcome in the use of oils is to effect their dilution to render them harmless to the plant. This dilution is effected with great accuracy by the kerosene-soap emulsions, and less accurately by the mechanical emulsions of oil and water. There have appeared during the last few years various so-called miscible oils, which readily and permanently mix with water, and can be applied with the same readiness and accuracy of strength as the emulsion of kerosene and soap. These oils have for their principal ingredient some form of petroleum rendered soluble by the addition of a percentage of vegetable oils and cut or saponified with an alkali, and they are, in fact, a sort of liquid petroleum soap. They are sold under various trade names.

They have the disadvantage of costing a good deal more than the standard emulsions or the lime-sulphur wash but have the great advantage of being always ready for immediate use without troublesome preparation. They can not be diluted for winter applications against scale insects with more than 10 or 15 parts of water to give good results, and there is some danger of injury to the trees if they are carelessly or excessively applied. They have, however, a very useful place, and especially as furnishing a good insecticide where only a few trees are to be treated and the owner would probably not go to the trouble of preparing an emulsion or the lime-sulphur wash. They have been so far principally used against the San Jose scale as dormant tree washes.

The Resin Wash.—The resin wash has proved of greatest value in California, particularly against the red scale and the black scale on citrus plants, and the last named and the San Jose scale on deciduous plants, and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the Northern States, the quicker acting and stronger kerosene washes and heavy soap applications are preferable. The resin wash acts by contact, having a certain caustic effect, but principally by forming an impervious, smothering coating over the scale insects. The application may be more liberal than with the kerosene washes, the object being to wet the bark thoroughly. The wash may be made as follows:

Resin	....pounds..	20
Crude caustic soda (78 per cent)	....do....	5
Fish oil	....pints..	2½
Water to make	....gallons..	100

Ordinary commercial resin is used, and the caustic soda is that put up for soap establishments, in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) may be used—3½ pounds of the latter being the equivalent of 5 pounds of the crude. Place these substances, with the oil, in a kettle with water to cover them to a depth of 3 or 4 inches. Boil about two hours, making occasional additions of water, or until the compound resembles very strong black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid, without sediment, and should any appear in the stock mixture reheating should be resorted to; in fact the wash is preferably applied hot.

As a winter wash for scale insects, and particularly for the more resistant San Jose scale, stronger washes are necessary. In southern California, for this insect, a dilution one-third less, or water to make 66 2/3 gallons instead of 100 (see formula), has given good results.

THE LIME-SULPHUR WASH.

Composition and Preparation.—In the matter of composition of the wash, scarcely any two experimenters agree. Salt was a part of the original composition of the sheep dip and has long been retained, with the idea that it added, perhaps, to the caustic qualities, and particularly to the adhesiveness of the wash. For the latter purpose a very small amount only, 1 or 2 pounds to the bushel of lime, need be added, following the custom in the preparation of whitewash mixtures. In practical experience, however, the salt seems to have been of very little benefit and is therefore omitted in the formula now given. The proportion of lime and sulphur is a matter of some indifference. The mixture obtained is sulphide of lime, and if an excess of lime is used it simply remains undissolved in the mixture and adds to the whitewashing character of the application. Too much lime is distinctly objectionable, however, because of the greater difficulty of spraying and harder wear on the pump and nozzles. The formula here given is substantially the one which has been hitherto recommended by this Bureau, reduced to the 45 or 50 gallon basis, or the capacity of the ordinary kerosene barrel commonly used in its preparation by the steam method.

Unslaked lime	pounds..	20
Flowers or flour of sulphur...........	do....	15
Water to make	gallons..	45 to 50

The flowers of sulphur, although requiring somewhat longer cooking, seems to make a better wash than ground sulphur, but the latter may be employed. Stone lime of good quality should be secured and slaked in a small quantity of water, say one-third the full dilution. The sulphur, previously mixed up into a stiff paste, should be added at once to the slaking lime. The whole mixture should be boiled for at least one hour, either in an iron kettle over a fire out of doors or in barrels by steam. Prolonged boiling increases the percentage of the higher sulphides, but the practical end is obtained by boiling for the time indicated. In the process of making, the color changes from yellow to the clear brown of sulphide of lime, except for the excess of lime floating in it. After an hour's boiling the full quantity of cold water can be added, and the mixture should then be promptly applied in order to get its full strength before the higher sulphides are lost by cooling and crystallizing out. In transferring to the spray tank it should be passed through an iron screen or strainer, and the tank itself should be provided with an effective agitator.

Directions for Use.—The wash is a winter application where used as an insecticide. It may be applied at any time after the falling of foliage in early winter and prior to the swelling of the buds in spring. The later the application can be made the better the results, and the best period is just before the buds swell in March or April. It will probably be necessary also to make this application every year, or at least as often as the San Jose scale develops in any numbers. The wash kills the San Jose scale not only by direct caustic action, but also by leaving the limy coating on the trees, which remains in evidence until midsummer or later and kills or prevents the settling of young scale insects which may come from parents escaping the winter action.

The wear on pumps and nozzles can be kept to a minimum by carefully washing the apparatus promptly after use. The use of an air or other gas pressure pump instead of the ordinary liquid pump will save the wear of the lime on the pump. In spraying with this wash clothing is ruined, and only the oldest garments should be worn. Care should be taken also to protect the eyes to avoid unnecessary inflammation.

Home Made Concentrated Lime Sulphur.—The various concentrated lime-sulphur solutions have been tested at other experiment stations and also tried out by orchardists, in some cases on an extended scale, and so far as observed have compared favorably with the regular home made lime-sulphur wash in efficiency. Their use became quite extensive during the past year, indicating that orchardists prefer buying the wash rather than make the solution. With this class of growers, the question of what brand to use is paramount. From these tests, it would seem that practically all the well known concentrated solutions can be expected to give good results if their standard is maintained. Every grower should procure a hydrometer and determine the density of the prepared wash and from that the dilution to be used.

It has been determined that the strength of a standard made mixture, that is, the degree of concentration, which is usually seven or more times as strong as the home made mixture, can largely be determined by its density or specific gravity provided there are no adulterations. Thus the hydrometer may be used to ascertain this density and dilution may then be made. Therefore, it is recommended that only well known or previously tested manufactured solutions be used. Any concentrated lime-sulphur preparation should test between 26½ and 32 degrees Beaume, and thus be diluted one to seven or nine respectively. The manufactured product should be a clear amber, reddish, or deep cherry colored liquid with very little sediment.

The Home Made Concentrated Lime-Sulphur.—The apparent efficiency, convenience in handling and readiness to start spraying at once when weather conditions are favorable have caused the rather extensive use of the different brands of concentrated solution in this state. The demand for this solution has caused several new brands to appear on the market, several of which are prepared by private parties, that is, persons who had special outfits for making the regular home made solution prepared the concentrated solution and offered it for sale in their respective vicinities.

It is thus possible for large orchardists who have previously made the home made solution at time of spraying to now make the concentrated at a time when spraying is impracticable, store it and have the solution ready for use when needed. The labor problem at spraying time is thus aided and advantage can be taken of half days or other times when conditions are favorable. Undoubtedly making the home concentrated is only practicable for those orchardists who require a large amount of solution. In such cases it is more economical, if the boiling outfit is intact, to make the concentrated than to buy from manufacturers.

The standard brands of concentrated are sold retail at about 20c a gallon in barrel lots. The lime usually costs about 50c per bushel and the sulphur 2¾c per pound. The grower can estimate what boiling and storing the solution will cost and compare the total with the present market price of commercial brands. For those who may desire to make their own concentrated mixture a formula is given below, which has been tested by this department in actual field operations and found to be effective.

Formula:

Lump lime	60 lbs.
Sulfur (flour or flowers)	125 lbs.
Water	50 gal.

Directions.—Slake lime to a consistency of thin paste, and add the sulfur. Stir the materials thoroughly to break up lumps. Boil vigorously for one hour. At start, enough water should be allowed to provide for evaporation in boiling. This will require from 10-15 gallons. The finished product may either be strained into barrels or other containers or it may be used at once after proper dilution. Home made concentrated should test 26 degrees to 32 degrees Beaume and should be diluted according to the table given on page 382.

In storing the solution, it is necessary to exclude air from it as much as possible by either filling up the barrel or other container completely with the solution, or by putting a film of oil on the surface of the liquid. The stored solution should be protected from extreme cold weather. According to Stewart, of the Pennsylvania Station, a solution of 1.28 density (32.1° Beaume) will not freeze at 5° F., and will usually recover completely should it be frozen at a lower temperature. If some crystals should form they may be strained out and redissolved by boiling and returned to the wash.

When ready for spraying the concentrated solution should be tested with the hydrometer, if this is not done after making, in order to determine the dilution that is desired. The table given above gives the dilutions for the respective densities on a basis of the regular home made solution.

The cooker used in making the regular lime-sulphur wash will serve to make the concentrated solution. This may be a home made vat, or a convenient iron boiler can be purchased for the work. Such boilers are often of use for other purposes on the farm.

The concentrated solution can be more easily made, of course, by boiling the mixture with steam coils in either wood or metal vessels, and, undoubtedly, those who have such outfits are more likely to undertake making this solution.

The Hydrometer.—In order to dilute the concentrated solutions in accordance with their degree of concentration and to be accurate they should be tested with a hydrometer. While this test will not reveal impurities, it will serve to indicate the proper dilution in a regularly prepared mixture. The hydrometer is a glass instrument, something like a thermometer in shape. In testing a liquid the hydrometer is placed in it bulb down, and the reading is made at the surface of the liquid in which it is supported. The instruments are made in two scales, the specific gravity and the Beaume. Both may be placed on the same instrument. Readings on the Beaume scale are given in degrees, while the reading on the specific gravity is given in decimals. The Beaume scale is easier to read and, while more difficult to estimate from, in this case will serve with the aid of the table given below. Hydrometers can be secured for about $1.25 from Arthur H. Thomas, of Philadelphia, Pennsylvania; Eimer & Amend, of New York City, and other dealers in such apparatus. In securing an instrument the range on Beaume scale should be 0° to 36° and 1.000 to 1.35 on the specific gravity scale.

TABLE FOR DILUTING CONCENTRATED SOLUTIONS.

Density Beaume Scale.	Density Specific Gravity Scale.	For San Jose Scale Dilute With Water At These Rates.
35	1.3181	1 to 9
34	1.3063	1 to 8½
33	1.2946	1 to 8
32	1.2831	1 to 7¾
31	1.2719	1 to 7½
30	1.2608	1 to 7
29	1.2500	1 to 6¾
28	1.2393	1 to 6½
27	1.2288	1 to 6
26	1.2184	1 to 5¾

—(Bul. 148, Md. Agr. Exp. Sta.)

Range of Usefulness.—This wash is distinctively the remedy for the San Jose scale and is particularly effective in applications to the smooth-barked fruit trees—such as peach, pear, and plum. In the case of the apple the terminal twigs are often covered with a fuzzy growth, more pronounced in some varieties than others, which prevents the wash from properly coating the bark. The young from scale insects which escape destruction at such points, for the reason indicated or from imperfect spraying, are driven out onto the new growth, or, in the case of fruit spurs, onto the fruit, so that a tree on which the scale has been pretty thoroughly exterminated may nevertheless present badly spotted fruit. In such cases the additional use of some one of the oil sprays may be necessary. This wash is of equal value against closely allied scale pests, such as Forbes's scale and the West Indian peach scale, and late sprayings are quite effective against the scurfy scale and the oyster-shell scale.

The spring application, just before the buds swell, has been demonstrated by Prof. J. M. Aldrich to kill most of the eggs of the apple aphis, and Fred Johnson, of this Bureau, has found that it is equally effective in destroying the eggs of the pear-tree Psylla. It is useful against other pests which hibernate about the leaf buds of fruit trees, as, for example, the pear-leaf blister-mite and the silvery mite of the peach, and in California Mr. Clark has shown that it is an entirely satisfactory remedy for the peach twig borer.

In addition to this range of usefulness against insect pests this wash has shown itself to be a valuable fungicide, notably for the peach leaf curl, sprayed trees being practically immune from this disease, so that the cost of treatment in the case of the peach is often more than made good by the fungicidal benefit alone. Later experience indicates its usefulness also as a winter application for apple scab and possibly for other plant diseases.

Time to Spray for Sucking Insects.—For the larger plant-bugs and the aphides, or active plant-lice, and all other sucking insects which are present on the plants injuriously for comparatively brief periods, or at most during summer only, the treatment should be immediate, and if in the form of spray on the plants, at a strength which will not injure growing vegetation.

For scale insects and some others, as the pear Psylla, which hibernate on the plants, two or more strengths are advised with most of the liquid insecticides recommended, the weaker for summer applications and the more concentrated as winter washes. The summer washes for scale insects are most effective against the young, and treatment should begin with the first appearance of the larvæ in the spring or any of the later broods, and should be followed at intervals of seven days with two or three additional applications. The first brood, for the majority of species in temperate regions, will appear during the first three weeks in May. Examination from time to time with a hand lens will enable one to determine when the young of any brood appear.

The winter washes may be used whenever summer treatment can not be successfully carried out, and are particularly advantageous in the case of deciduous plants with dense foliage which renders a thorough wetting difficult in summer, or with scale insects which are so irregular in the time of disclosing their young that many summer treatments would be necessary to secure anywhere near complete extermination. In the winter also, with deciduous trees, very much less liquid is required, and the spraying may be much more expeditiously and thoroughly done. In the case of badly infested trees, a vigorous pruning is advisable as a preliminary to treatment.

DUSTING AND SPRAYING APPARATUS.*

Powder Distributers.—For the application of powders the dusting bags already described are very satisfactory for field work. Much more expensive and more rapid machine distributers have been devised, but these are rarely used. For garden work some of the small powder bellows and blowers are excellent. These cost from $2 to $8.

Liquid Sprayers.—For the application of poisons in liquid form the prime essential is an apparatus which will break up the liquid into a fine mist-like spray that will coat every leaf and every other part of the plant as lightly as is compatible with thoroughness. The essential features of such an apparatus are the force pump, suitable hose, and nozzles or spray tips. The leading pump manu-

* For illustrations, see pages 141, 159, 231, 249, 384, 458.

facturers now put out a large variety of spraying apparatus suited for all ordinary needs, including the small knapsack pumps, barrel and tank pumps, and geared and power sprayers. For limited indoor operations a hand atomizer or even a sprinkling can with fine rose tip may be made to do fair service.

The Barrel Pump.—This is the commonest form of spraying apparatus, and is supplied in many different styles; or, a suitable spray pump can be combined with an empty 50-gallon kerosene barrel without much difficulty. This apparatus may be hauled about on a sled or in a wagon or a two-wheeled cart.

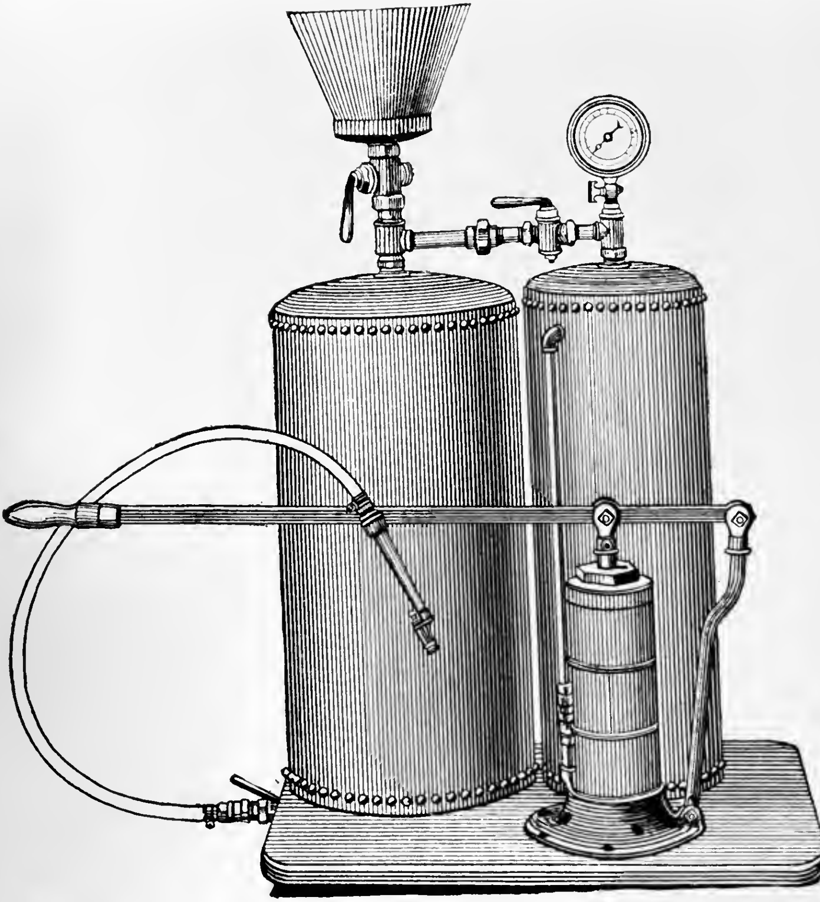
Tank Outfits.—For larger operations it is much better to have a specially constructed rectangular or half-round spray tank of a capacity of 200 or 300 gallons. Such an apparatus enables an elevated platform to be mounted on the wagon and tank, greatly facilitating spraying of the higher parts of trees, as indicated in the accompanying illustration. The ideal sprayer for extensive work combines such a tank, with platform, with gasoline or steam power spray pump.

Geared Sprayers.—For low-growing regularly planted crops it is sometimes possible to use spraying apparatus which gets its power by means of a sprocket wheel from the axle of the wagon. Several types of spraying apparatus of this kind are on the market, suited especially for the treating of crops like potatoes and strawberries, and the spraying of vineyards. In orchards it is not often possible to have the wagon constantly in motion, and geared sprayers are not as a rule available.

Gas-Pressure Sprayers.—Some very successful spraying machines have been made which have as their motive power gas pressure. This pressure may be derived from compressed air or carbonic acid gas cylinders. It is an ideal way of applying liquid sprays, and has a special applicability to oil-water mixtures. Ultimately this principle may come into much more general use.

Hose, Nozzle, and Agitator.—The hose and nozzle are two very essential elements of a good spraying apparatus. The very best three-eighths, one-fourth, or one-half inch 3-ply or 4-ply hose should be bought. A cheap or inferior hose will not stand the pressure and heavy wear of spraying. For orchard spraying a length of 25 feet is the least that should be used, and better 35 feet, and longer with large apparatus where it may be possible to spray more than one row at a time. Several lines of hose may be operated with a strong spray pump. Each line of hose should be supplied with an extension rod 8 or 10 feet long. This rod may be an ordinary bamboo pole into which a small brass tube is fitted carrying the nozzle, or the hose may terminate in a small gas pipe—a rather heavy device and useful for short length only. The best nozzle for general use is the "Friend type."

A very necessary feature of spray tanks is a device for keeping the liquid constantly agitated to keep up a uniform mixture or prevent the settling of the poison or solid constituents of the wash. This may be accomplished by constant stirring with a paddle. Most



Compressed Air Pump, Suitable for Spraying a Mechanical Mixture of Oil and Water. Dept. of Agr.

Derrick in Position on Each Side of Tree Supported by Guy Ropes; Pulleys Hooked to Catch Rings in the Tent. Dept. of Agr.

of the spraying apparatus now on the market are provided with automatic agitators.

Selection of Spraying Outfit.—For limited garden work or for the treatment of low plants a simple bucket pump can be used which will cost about $6, or the knapsack pump, costing about $14. For home orchards of small size a barrel pump with one line of hose will serve every purpose, the complete outfit costing $12 to $18. For larger operations, with two lines of hose and nozzles, a barrel outfit, costing from $25 to $30, may be used. Tank outfits, with double cylinder pumps suitable for an orchard of a thousand bearing trees, may be obtained at a cost of from $75 to $90. The power sprayers are quite expensive, costing $200 to $300 or more.

Directions for Spraying.—Thorough work in spraying must be done, or failure will result. To accomplish this, power sufficient to break up the liquid into a fine mist is essential. This makes it possible for the tree to be thoroughly and thinly wetted with the spray without waste, and the ideal application is to accomplish this without causing the liquid to collect in drops and fall from the tree. More of the spray is left on the leaves with a light spray than with a heavy application, which causes the globules to coalesce and a shower of drops to fall to the ground. To get a proper spray, it should be possible to produce a pressure of at least 75 pounds, or, with power outfits, of 125 to 150 pounds.

Fruit trees of average size or, if apple, such as would produce 10 or 15 bushels of fruit, will require from 3 to 7 gallons of spray to wet them thoroughly. For smaller trees, such as plum and cherry, 1 gallon to the tree may be sufficient. In spraying orchard trees and other fruit trees it will often be found convenient, especially with a smaller apparatus, to spray on each side half of each tree in a row at a time, and finish on the return. A light rain will remove comparatively little of the poison, but a dashing rain may necessitate a renewal of the application.

Hydrocyanic-acid Gas Treatment.—The use of hydrocyanic-acid gas originated in southern California in work against citrus scale insects, and was perfected by a long period of experimentation by an agent of this Bureau, Mr. D. W. Coquillett. It is undoubtedly the most thorough method known for destroying scale insects and especially is it the best treatment for citrus trees, the abundance of foliage and nature of growth of which render thorough spraying difficult, but, on the other hand, enable the comparatively heavy tents employed in fumigation to be thrown or drawn over the trees rapidly without danger of breaking the limbs. One good gassing is usually the equivalent of two or three sprayings, the gas penetrating to every particle of the surface of the tree and often effecting an almost complete extermination, rendering another treatment unnecessary for two years or more.

Another very important use for hydrocyanic-acid gas is as a means of controlling insect pests in greenhouses and cold frames. The process is a special one, however, and entails considerable variation, owing to the wide range of plants to be considered. A more recent use for this gas is in disinfecting houses of insect pests and vermin. *In all work with hydrocyanic-acid gas, its extremely poisonous nature must be constantly kept in mind and the greatest precautions must be taken to avoid inhaling it.*

Fumigation of Nursery Stock.—For the fumigation of nursery stock or imported plant material in a dormant or semidormant condition, a building or room should be provided, which can be closed practically air-tight, and it should be fitted with means of ventilation above and at the side, operated from without, so that the poisonous gas can be allowed to escape without the necessity of anyone entering the chamber. The gas is generated by combining potassium cyanide, sulphuric acid, and water. The proportions of the chemicals are as follows: Refined potassium cyanide (98 per cent), 1 ounce; commercial sulphuric acid, 1 ounce; water, 3 fluid ounces to every hundred cubic feet of space in the fumigating room. For comparatively green or tender material the same amounts may be used to 150 cubic feet of space.

The generator of the gas may be any glazed earthenware vessel of 1 or 2 gallons capacity and should be placed on the floor of the fumigating room, and the water and acid necessary to generate the gas added to it in the order named. The cyanide should be added last, preferably in lumps the size of a walnut, and the premises promptly vacated and the door made fast. Treatment should continue forty minutes.

ORCHARD FUMIGATION.

Amounts of Chemicals to Use.—The amounts of chemicals used vary with the size of the tree and, as now employed in California, are considerably in excess of the amounts recommended as recently as 1898. The gas treatment was first chiefly used against the black scale and at a season of the year when these scales were all in a young stage and easily killed. The effort is now made not only to kill the black scale, but also the red and purple scales, and to do more effective work than formerly against the black scale. The amounts of chemicals ordinarily advised and commonly employed in Los Angeles, Orange, and some other counties in southern California are indicated in the subjoined table, published by the horticultural commissioners of Riverside County, Cal.

Amounts of Chemicals and Water Ordinarily Used for Trees of Different Sizes.

Height of tree.	Diameter of tree.	Water.	Cyanide, C. P., 98 per cent.	Sulphuric acid, 66 per cent.
Feet.	*Feet.*	*Ounces.*	*Ounces.*	*Ounces.*
6	4	2	1	1
8	6	3	1½	1½
10	8	5	2½	2½
12	14	11	5	5½
16	16	17	8	9
20	16–20	22	10	12
20–24	18–22	30	14	16
24–30	20–28	34	16	18
30–36	25–30	52	24	28

The proportions here recommended are thoroughly effective for the black scale at the proper season, and measurably effective also for the California red scale and the purple scale. Where the treatment is designed to be one of extermination for these latter scale pests, from one-third to one-half more of cyanide and acid is employed, as indicated by the subjoined table, furnished by Mr. G. Havens, of Riverside. The amounts here recommended may be employed also for compact trees with dense foliage or in moist coast regions where stronger doses are needed.

Excessive Amounts of Chemicals Used for Absolute Extermination of Scale Insects.

Height of tree.	Diameter through foliage.	Water.	Sulphuric acid.	Cyanide.	Time to leave tent on tree
Feet.	*Feet.*	*Fluid ozs.*	*Fluid ozs.*	*Ounces.*	*Minutes.*
6	3- 4	3	1½	¾- 1	20
8	5- 6	6	2½	2	30
10	7-10	15	5- 6	4 - 5	35-40
12	9-12	20- 30	7- 9	5½- 7½	40
14	12-14	30- 35	9-12	8 -10	40
16	12-15	35- 40	12-14	10 -12	40
18	14-16	45- 55	15-18	12 -15	40-50
20	16-18	60- 70	20-22	16 -20	45-50
22	16-18	70- 75	22-25	20	50
24	18-20	75- 80	25-30	22 -26	50
27	20-24	85-100	30-36	28 -32	60
30	20-28	100-110	36-44	32 -38	60

The duration of the treatment indicated in the second table varies with the size of the tree, but in general at least forty minutes should be allowed.

In Florida fumigation for the white fly can be successfully practiced only during the short period in winter when the insect does not occur in the winged stage. This period covers from two and a half to three months, namely, December, January, and February, varying with the climatic conditions of different years. This is the dry season for Florida, and the trees are in a dormant condition, with the leafage well matured and hardened, and it is possible to apply a greater strength than would be safe under California conditions. The strength recommended is approximately the same as for deciduous nursery stock, viz., 1 ounce of cyanide to 100/115 cubic feet of space, with a duration of 40 minutes.

General Directions.—In the fumigation of growing stock, citrus or other, the treatment consists in inclosing the tree with a tent and filling the latter with poisonous fumes generated in the same way as described for nursery stock except that less of the chemicals is used. The treatment is made at night for trees in foliage, which includes all work in citrus orchards, to avoid the much greater likelihood of injury to tender foliage in the sunlight. The vessels for setting off the charges of cyanide and acid may be, for small doses, any ordinary earthenware jars. For large trees requiring heavy doses, tall wooden pails have proved more satisfactory, two generators being employed for the very largest trees.

It is important that the water be put in the vessel first, then the acid, and lastly the cyanide. If the water and cyanide are put in the vessel first and the acid poured in afterwards, there is danger of an explosion which will scatter the acid and burn the tents and the operator. In the spring, when the trees are tender with new growth, and in early fall when the oranges are nearly grown and the skins are likely to be easily marred, and also with young trees, it is advisable to add one-third more water than ordinarily used, or to add the cyanide in larger lumps. This causes the gas to generate more slowly and with less heat, and, if the tents are left over the trees a third longer, the effectiveness of the treatment will not be lessened. The person handling the chemicals should always have an attendant with a lantern, to hold up the tent and enable the cyanide to be quickly dropped into the generator, and to facilitate the prompt exit of the operator.

Trees are fumigated for the black scale in southern California in October, or preferably in November. The red and other scales may be treated with gas at any time, but preferably at the season already indicated. In California most of the work is done by contract, or under the direct supervision of the county horticultural commissioners, in some cases the tents and material being furnished at a merely nominal charge, together with one experienced man to superintend the work, while a crew of four men operate the tents, the wages of the director and men being paid by the owner of the trees.

*Construction and Handling of Tents.**—The tents now employed are of two kinds, the sheet tent of octagonal shape for large trees, and the "ring" tent for trees under 12 feet in height. The ring tents, or, as they are also called, the bell tents, are bellshaped and have a hoop of half-inch gas pipe fastened within a foot or so of the opening. Two men can easily throw one of these tents over a small tree. An equipment of 36 or 40 ring tents can be handled by four men. They are rapidly thrown over the trees by the crew, and the director follows closely and introduces the chemicals. By the time the last tent has been adjusted the first one can be removed and taken across to the adjoining row. An experienced crew, with one director, can treat 350 to 400 5-year-old trees, averaging 10 feet in height, in a single night of eleven or twelve hours. The cost under such conditions averages about 8 cents a tree.

With large trees the large sheet tents are drawn over them by means of uprights and pulley blocks. Two of these sheets are necessary for very large trees, the first being drawn halfway over and the second drawn up and made to overlap the first. In the case of trees from 24 to 30 years old and averaging 30 feet in height, about 50 can be treated in a night of ten or twelve hours with an equipment of 12 or 15 tents, the cost being about 75 cents per tree. It is not practicable to treat trees above 30 feet in height.

The handling of the bell tents is simple and needs no further description, but the large tents are not so easily operated, and the method of adjusting the great flat octagonal sheets over the trees,

* For illustrations, see pages 87, 104, 384.

while simple enough when once understood, warrants a description. The machinery employed consists of two simple uprights, with attached blocks and tackle. The uprights are about 25 feet high, of strong Oregon pine, 2 by 4 inches, and are provided at the bottom with a braced crossbar to give them strength and to prevent their falling to either side while the tent is being raised. A guy rope is attached to the top of each pole and held to steady it by a member of the crew stationed at the rear of the tree. The tent is hoisted by means of two ropes 70 feet long, which pass through blocks, one fixed at the top of the pole and the other free. The tent is caught near the edge by taking a hitch around some solid object, such as a green orange, about which the cloth is gathered. By this means the tent may be caught anywhere without the trouble of reversing and turning the heavy canvas to get at rings or other fastenings attached at particular points. The two remaining members of the operating crew draw the tent up against and over one side of the tree by means of the pulley ropes sufficiently to cover the other side of the tree when the tent falls. The poles and tent together are then allowed to fall forward, leaving the tent in position. Sufficient skill is soon acquired to carry out rapidly the details of this operation, so that little time is lost in transferring the tents from tree to tree, even when the trees approximate the limit in height. A single pair of hoisting poles answers for all the tents used.

Some of the tents employed are of great size, one described by Mr. Havens having a diameter of 76 feet. It is constructed of a central piece 50 feet square, of 10-ounce army duck. Four triangular side pieces or flaps of 8-ounce duck, 10 feet wide in the middle, are strongly sewed to each side of the central sheet, forming an octagonal sheet 70 feet in diameter. About the whole sheet is then sewed a strip of 6-ounce duck, 1 yard wide. The tent is handled by means of ropes and pulleys. A 1½-inch manila rope is sewed about the border of the central piece in an octagonal pattern. Rings are attached to this rope at each of the eight corners thus formed, and also on either side of the tent. To these rings the pulley ropes are fastened, and the tent is elevated over the trees and handled with comparative ease.

The canvas for the tents, blue or brown drilling or 8 to 10 ounce duck, may be rendered comparatively impervious to the gas by painting lightly with boiled linseed oil. This has the objection, however, of stiffening the fabric and adding considerably to its weight; it also frequently leads to its burning by spontaneous combustion unless carefully watched until the oil is dry. A much better material than oil is found in a product obtained from the leaves of the common prickly pear cactus, which grows in abundance in the Southwest. The liquor is obtained by soaking chopped-up leaves in water for twenty-four hours. It is given body and color by the addition of glue and yellow ocher or venetian red, and is applied to both sides of the canvas and rubbed well into the fiber of the cloth with a brush.

Some practical experience is necessary to fumigate successfully, and it will therefore rarely be wise for anyone to undertake it on a large scale without having made preliminary experiments.

Bisulphid of Carbon Vapor.—In line with the use of hydrocyanic-acid gas is the employment of the vapor of bisulphid of carbon to destroy insects on low-growing plants, such as the aphides on melon and squash vines. The treatment, as successfully practiced by Professors Garman and Smith, consists in covering the young vines with small tight boxes 12 to 18 inches in diameter, of either wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls (1 or 2 drams) of the very volatile liquid bisulphid of carbon. The vines of older plants may be wrapped about the hill and gathered in under larger boxes or tubs, and a greater, but proportional, amount of the liquid used. The covering should be left over the plants from three-quarters of an hour to an hour, and with 50 to 100 boxes a field may be treated with comparative rapidity.

Bisulphid of carbon has proved also to be the most effective means of disinfecting grape cuttings suspected of being infested with phylloxera. The cuttings are inclosed in a tight barrel or fumigating box, and the bisulphid of carbon, poured out in a shallow dish, is put on top of the cuttings. An ordinary saucerful of the chemical is enough for a box 3 feet cube. The treatment lasts from forty-five to ninety minutes. This is a pretty strong fumigation, but the dormant condition of the cuttings makes this possible.

REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wireworms, apple and peach root-aphides, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried down by water. Of this sort are the kerosene emulsions and resin wash—the former preferable—the potash fertilizers, muriate and kainit, and bisulphid of carbon. The simple remedies are applications of strong soap or tobacco washes to the soil about the crown; or soot, ashes, or tobacco dust buried about the roots; also similarly employed are lime and gas lime. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has proved of the greatest service against the phylloxera.

Hot Water.—As a means of destroying root-aphides, and particularly the woolly aphis of the apple, the most generally recommended measure hitherto is the use of hot water, and this, while being both simple and inexpensive, is thoroughly effective, as has been demonstrated by practical experience. Water at nearly the boiling point may be applied about the base of young trees without the slightest danger of injury to the trees, and should be used in sufficient quantity to wet the soil thoroughly to a depth of several inches, as the aphides may penetrate nearly a foot below the surface.

To facilitate the wetting of the roots and the extermination of the aphides, as much of the surface soil as possible should be first removed.

By a hot-water bath slightly infested stock can be easily freed of the aphides at the time of its removal from the nursery rows. The soil should be dislodged and the roots pruned, and in batches of a dozen or so the roots and lower portion of the trunks should be immersed for a few seconds in water kept at a temperature of 130° to 150° F. A strong soap solution similarly heated or a fifteen times diluted kerosene emulsion will give somewhat greater penetration and be more effective, although the water alone at the temperature named should destroy the aphides.

Badly infested nursery stock should be destroyed, since it would be worth little even with the aphides removed.

Tobacco Dust.—Some very successful experiments conducted by Prof. J. M. Stedman demonstrated the very satisfactory protective, as well as remedial value of finely ground tobacco dust against the woolly aphis. The desirability of excluding the aphis altogether from nursery stock is at once apparent, and this Professor Stedman shows to be possible by placing tobacco dust freely in the trenches in which the seedlings or grafts are planted and in the orchard excavations for young trees. Nursery stock may be continuously protected by laying each spring a line of the dust in a small furrow on either side of the row and as close as possible to the tree, and covering loosely with earth. For large trees, both for protection and the destruction of existing aphides, from 2 to 5 pounds of the dust should be distributed from the base outward to a distance of 2 feet, first removing the surface soil to a depth of from 4 to 6 inches. The tobacco kills the aphides by leaching through the soil, and acts for a year or so as a bar to reinfestation. The dust is a waste product of tobacco factories, costs about 1 cent per pound, and possesses the additional value of being worth fully its cost as a fertilizer.

Kerosene Emulsion and Resin Wash.—Either the kerosene-and-soap emulsion or the resin wash, the former diluted fifteen times and the latter at the strength of the winter mixture, are used to saturate the soil about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-aphis of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant and pour in 5 gallons of the wash. If not a rainy season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring, when the more frequent rains will take the place of the waterings.

For root-maggots enough of the wash is put at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably followed after an hour with a like amount of water. For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvæ go to deeper and deeper levels and eventually die.

Potash Fertilizers.—For white grubs, wireworms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either kainit or the muriate of potash—the former being the better—are broadcasted in fertilizing quantities, preferably before or during a rain, so that the material is dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil, but are deterrents, and truck lands constantly fertilized with these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and greater resisting power of the plants, which of itself more than compensates for the cost of the treatment.

For the root-aphis of peach and apple, work the fertilizer into the general surface of the soil about the trees, or put it into a trench about the tree 2 feet distant from the trunk. For cabbage and onion maggots, apply in little trenches along the rows at the rate of 300 to 500 pounds to the acre, and cover with soil. These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for hibernation or to undergo transformation.

Bisulphid of Carbon.—This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting aphides. The treatment is made at any season except the period of ripening of the fruit and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of the bisulphid, and closing the holes with the foot. The injections are made about 1½ feet apart, and not closer to the vines than 1 foot. It is better to use a large number of small doses than a few large ones. Hand injectors and injecting plows are employed in France to put the bisulphid into the soil about the vines, but a short stick or iron bar may take the place of these injectors for limited tracts.

The use of bisulphid of carbon for the woolly aphis is the same as for the grape root-aphis or phylloxera. It should be applied in two or three holes about the tree to a depth of from 6 to 12 inches and not closer than 1½ feet to the tree. An ounce of the chemical should be introduced into each hole, which should be immediately closed.

For root-maggots a teaspoonful is poured into a hole near the base of the plant, being covered as above. For ant nests an ounce of the substance is poured into each of several holes made in the space occupied by the ants, the openings being then closed; or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

Submersion.—This very successful means against the phylloxera is now practiced over some 75,000 acres of vineyards in France which were once destroyed by the grape root-aphis, and the produc-

Maple Tree Defoliated by Green-Striped Maple Worm, Kansas City. Dept. of Agr.

tion and quality of fruit has been fully restored. In this country it will be particularly available in California and in all arid districts where irrigation is practiced; otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours; in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine has ceased, or during September or October, but while the phylloxera are still in active development. Early in September eight to ten days will suffice; in October fifteen to twenty days, and during the winter, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight hour flooding, is customary to reach any individuals surviving the fall treatment, and which in midsummer are very susceptible to the action of water.

To facilitate the operation, vineyards are commonly divided by embankments of earth into square or rectangular plats, the former for level and the latter for sloping ground, the retaining walls being protected by coverings of reed grass, etc., during the first year, or until they may be seeded to some forage plant.

This treatment will destroy many other root-attacking insects and those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

General Methods of Treatment.—The chief loss from insects of this class is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators, although in the warmer latitudes much injury results from infestation in the field between the ripening of the grain and its storage in bins or granaries. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive operations, such as, in the South, prompt thrashing of grain after harvesting, the thorough cleansing of bins before refilling, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of weeviled grain, there are four valuable remedial measures, viz, agitation of the grain, heating, dosing with bisulphid of carbon, and fumigating with sulphur dioxid.

The value of agitating or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another, grain pests are not likely to trouble. The benefit will depend upon the frequency and thoroughness of the agitation. In France machines for shaking the grain violently have been used with success. Winnowing weeviled grain is also an excellent preliminary treatment.

Bisulphid of Carbon.—This is a colorless liquid with very offensive odor, which, however, passes off completely in a short time. It readily volatilizes, and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisulphid in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. Prof. H. E. Weed reports that in Mississippi the chemical is commonly poured directly onto the grain. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover them over with a blanket to prevent the too rapid dissipation of the vapor. The bins or buildings should be kept closed from twenty-four to thirty-six hours, after which a thorough airing should be given them.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain. The bisulphid is applied at the rate of 1 pound to the ton of grain, or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters and to guard against fire. The bisulphid should be first distributed in the upper story, working downward as rapidly as possible to avoid the settling vapor, using the substance very freely in waste or dishes at all points of infestation and over bins throughout the building. If the building be provided with an exterior means of descent (such as a fire escape) it would be preferable to begin with the lower story and work upward.

This insecticide may also be used in other stored products, as peas, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight can, chest, or closet for treatment. It may also be employed to renovate and protect wool or similar material stored in bulk. The bisulphid costs, in 50-pound cans, 10 cents per pound, and in small quantities, of druggists, 25 to 35 cents per pound.

The bisulphid may be more freely employed with milling grain than with that intended for seeding, since, when used excessively, it may injure the germ. It must always be remembered that the vapor is highly inflammable and explosive, and that no fire or lighted cigars, etc., should be in the building during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small outbuilding.

While this gas is not especially dangerous to human beings, care should be taken to avoid unnecessary inhalation. It has a slight suffocating effect, and if inhaled for some time produces dizziness, which should be a warning to the operator that it is time to seek fresh, pure air.

Sulphur Dioxid.—The fumes of burning sulphur, namely, sulphur dioxid, with some sulphur trioxid, have long been one of the standard insecticide gases for the destruction of insect pests in rooms or dwellings, and notably for the bedbug (*Cimex lectularius* L.). Doctor Stiles, of the Public Health and Marine-Hospital Service, reports very successful fumigation and disinfection of frame cottages at a seaside resort for bedbug infestation by burning sulphur at the rate of 2 pounds of stick sulphur for each 1,000 cubic feet of space. Sulphur candles for such fumigation are a standard supply material to be purchased anywhere. Sulphur fumes are also employed for disinfection from disease germs, and also in the more recent yellow-fever work for the destruction of mosquitoes in dwellings. The chief objection to the sulphur fumigation arises from the strong bleaching action of the fumes in the presence of moisture and their powerful destructive action on vegetation.

For the disinfection of ships and ships' cargoes, particularly of grain, sulphur dioxid, under the name of Clayton gas, is now being extensively employed. These experiments showed that sulphur dioxid, under pressure such as can be maintained in an air-tight compartment or in the hold of a ship, has great penetrating power and is very efficient as a means of destroying all kinds of insects. The germinating power of seeds is quickly destroyed, but no injury results to the feeding or cooking quality of cereals. It can not be employed in the case of living plants, nor with moist fruits or products, such as apples or bananas. The best results in the case of insects infesting grain and seed, such as Calandra and Bruchus, which are often inclosed in the seeds, were obtained by the use of a low percentage (1 to 5 per cent of gas) for a period of twelve to twenty-four hours. Employed in this way the gas is a very effective means of disinfecting stored grain or similar products not intended for planting, and has the additional advantage of entirely eliminating the danger of explosion and fire.—(F. B. N. Y. Dept. of Agr.).

HEAT METHOD OF CONTROL.

The treatment by heat, while new in its application to entire buildings, has during the past two years been used very successfully, both in the control of the Indian-meal moth and in that of the related Mediterranean flour moth. It is, of course, only applicable to mills heated by steam. In the proper application of this method the mill should be thoroughly piped and furnished with suitable radiators. Sufficient radiator surface should be supplied to obtain a temperature of 120° to 125° F. A few courses of 1¼-inch pipe placed along the side walls should easily bring about the desired results. If a warm day in the summer is selected and the steam is employed at a pressure of 75 to 100 pounds, only a small amount of radiator surface is needed. To permit the most effective penetration of the heat, the bags of nuts should be piled only a few feet deep, as experience has shown that some time is required for the peanuts within the piles to be raised to a uniform high temperature. The building should be closed tightly and the temperature raised to 120° F., remaining at this point for at least 6 hours. A longer time is advisable, as the penetration is thereby increased. Bags of shelled stock are with difficulty heated to the center without a long exposure, and although the larvæ work near the outside of the bags they may crawl to the center to escape the great heat, which tends to make them much more active.

The temperature should not be raised above 125° F. in the case of peanuts, as experiments have shown that a slight degree of blanching, or slipping of the skin, takes place in shelled Spanish nuts exposed to such a heat. Virginia peanuts, being much less oily, are not affected, while no injury whatever takes place in the case of unshelled nuts. Germination is likewise unaffected, peanuts exposed 6 hours to a temperature of 140° germinating better and more quickly than those unheated. A temperature of 116° is fatal to insect life in a short time, larvæ, pupæ, and adults of the Indian-meal moth dying in less than one-half hour, when exposed.

SUBSTANCES THAT REPEL.

There are a number of substances that are more or less useful for the purpose of driving insects away from places where they would do harm if unmolested. I give below a few of the most important.

Napthaline, Gum-camphor, and Moth Balls.—Napthaline crystals are much used in insect boxes and in boxes or trunks where furs, feathers or woolen goods are kept, for the purpose of keeping out insects that feed on these animal products. It is probably the best single chemical that can be used for this purpose. Gum-camphor is also much used for the same purpose and moth-balls are a combination of these two volatile substances. These materials cannot be used to kill insects, but only to repel them.

Tobacco.—Tobacco, in the form of dust, or otherwise, is often used for the same purpose as the preceding, but to be effectual must be used quite freely.

Ashes.—Ashes, particularly from wood, are frequently used to dust upon plants after a rain or while the dew is on and often result in the insects disappearing. Particularly is this true in case of flea-beetles and the cucumber beetle when feeding upon leaves. Ashes do not kill the insects, but they make the food distasteful, so the insects are driven to other plants.

Lime, Plaster, and Road Dust.—These substances are also used like ashes as repellents, but are of little or no use for the destruction of insects.—(Bul. 71, Col. Agr. Exp. Sta.)

Phosphorus.—Proprietary preparations containing this substance as their active ingredient are to be bought of most druggists, and are effective against roaches and some other vermin infesting dwellings. They contain only a small percentage (about 1.50) of phosphorus, the rest consisting ordinarily of sugar, sirup and starch.

Oil of Citronella.—This oil has a rather pleasant but very persistent odor, and is frequently employed as a deterrent against mosquitoes. In sand and soil a few drops of it persist for weeks, and even months, which property recommends it for use against insects attacking the young corn plant immediately after it germinates, the oil being applied to the seed before planting. The oil is obtained from a grass, *Andropogan nardus,* of Ceylon and other eastern countries, where it is said to be regarded as a remedy for rheumatism when rubbed on the affected parts.

Sticky Preparations, Tanglefoot, Etc.—Adhesive preparations are of value for insects which creep up or down the trunks of trees, and have become well-known in most households from their use in the form of sticky fly-paper. The sticky substance can be bought in cans and pails of the manufacturer, O. & W. Thum Co., Grand Rapids, Mich. It may be applied directly to the bark as a deterrent against the attacks of peach and other borers, or may be used on bands of paper, tin, or straw-board, secured about the trunk. For the elm leaf-beetle we have used at the Station a trough-shaped band made of carpet paper, or tin, securing its lower edge close against the tree, but leaving the upper edge free and at a distance of several inches from the trunk. The inside of the trough is smeared with the sticky material, which entraps large numbers of the descending larvæ. Used in connection with spraying arsenate of lead on the leaves, it affords a very satisfactory means of keeping the elm pest in subjection.

Tar.—This substance was once used for the canker worm of apple, being applied to the trunk to keep the wingless females from ascending. It hardens when exposed, and proves very injurious to the trees when applied directly to the bark. The latter difficulty can be avoided by using tarred bands, and the former by renewing the tar from time to time. The sticky papers can be made to serve every such purpose, however, and are much more convenient. For soil-infesting seed-eating insects, such as the wire-worm, tar may be used with good effect. A teaspoonful is stirred among about a peck of shelled corn after dampening with a little warm water. It should then be allowed to dry before planting.—(Bul. 147, Ken. Exp. Sta.)

Records kept of the entire cost of spraying and of the yield and value of the fruit from the sprayed and unsprayed trees, showed that spraying produced a net gain per tree of $1.70 in one orchard and of $2.56 in the other orchard. It increased the yield of fruit by 1.7 bushels per tree in one orchard and by 2.1 bushels per tree in the other orchard. The improvement in the quality of fruit was also very noticeable. In one orchard the sprayed trees gave 44.9 per cent of No. 1 fruit while the unsprayed trees gave only 4 per cent of No. 1 fruit. In the other orchard 61.8 per cent of the crop on the sprayed trees was first grade fruit while only 22.4 per cent of the crop on the unsprayed trees was first grade. The cost of spraying was found in one orchard to be 28.8 cents per tree for four sprayings, and 40.3 cents per tree in the other orchard for five sprayings.—(Bul. 106, Neb. Agr. Exp. Sta.).

The following tables give the itemized cost of spraying with a barrel pump:

Material.

Bordeaux Mixture.		
3 pounds of copper sulfate at 8c...........	$0.24	
4 pounds lime at 1c	.04	
		$0.28
Arsenate of lead, 2 pounds at 20c, or Paris green, ½ pound at 25c.................		.40
Total cost of spray material per barrel....		$0.68
One barrel (50 gallons) covers 20 20-year-old apple trees, or cost of material per tree		.034

Labor.

Two men at $1.50 per day...............	$3.00	
One horse at $1.50 per day	1.50	
		$4.50
Will cover 150 trees per day, or labor per tree		0.03
Total cost per tree for one spraying.......		$0.064
Cost of first spraying with copper sulfate only		.038
Total cost of four sprayings per tree........		.23

Profit from Spraying an Orchard of 100 Trees.

Average gross profit per tree, based on above experiments, at $1.25.........................		$125.00
Four sprayings at 23c., or say 25c. per tree	$25.00	
20% on $40 invested in the best outfit..	8.00	
		33.00
Net profit		$92.00
Less cost of outfit		40.00
Net profit for first year (80% on total investment)		$52.00

Can You Afford Not to Spray? Can You Make Money More Easily?—(Bul. 131, New Hamp. Agr. Exp. Sta.)

BENEFICIAL INSECTS.

PARASITES.

Insects are beneficial to man in numerous ways, as furnishing food and clothing (as honey and silk), materials used in the arts and sciences, as cochineal dye, shellac, Chinese white, and in some countries they are an article of food. By far the greatest benefit comes, however, from their warfare among themselves, whereby noxious species are kept reduced. For present purposes insects may be considered as parasitic and predaceous.

Parasitic Insects.—These are mostly small to minute wasps, but also some two-winged flies, which deposit their eggs in or on the eggs, larvæ, or pupæ of their hosts, on which the resulting larvæ feed. The hymenopterous families of Ichneumonidæ, Braconidæ, Chalcididæ, and Proctotrypidæ are largely composed of insects which parasitize other species, rendering enormous service to the fruit grower. Species of Microgaster attack sphinx and other larvæ in vineyards and elsewhere, and one often sees a feeble caterpillar with its back covered with the brilliant white bodies of the cocoons of these parasites. Plant lice are parasitized by species of Aphidius, the adult cutting a round hole in the back of its host on leaving, and the chalcis flies attack the smaller insects or even eggs, and include a long list of highly beneficial forms. The chalcis fly destroys the eggs of the codling moth, the cotton bollworm, and cotton-leaf caterpillar. Proctotrypids are among the smaller insects, and parasitize principally the eggs of other species.

In the Diptera the bee flies (*Bombylidæ*) parasitize the larvæ and pupæ of moths and wasps, and also the egg sacs of grasshoppers. Larvæ or maggots of Tachnid flies are parasites principally of caterpillars, and are important checks to the increase of injurious insects.

Predaceous Insects.—These are predatory insects, searching out their prey, which they attack and destroy. Predaceous insects include those with sucking and biting mouth parts. Among the former are the assassin bugs, as the blood-sucking cone-nose and the wheel bug; also the spined soldier bug and the little Triphleps. These all impale their victim on their beak, sucking out the body juices. Among the latter are the praying mantis, tiger beetles, ladybirds, and wasps, some of which latter paralyze their prey, to be stored in their nests for future use of their young. The ladybirds (*Coccinellidæ*) constitute a large family of small hemispherical beetles more or less marked with red, yellow, or black, which feed on plant lice and scale insects. Numerous attempts have been made to establish these in orchards, to secure the subjugation of destructive species, as the importation of the Vedalia, which now controls the cottony cushion scale in California, and the Chinese ladybird, brought over from China to destroy the San José scale. While it is a pleasing proposition to secure the control of insects by arraying them against each other, in general, the fruit grower must depend on the intelligent use of sprays.—(U. S. E. S. B. 178).

BEES.*

Bee culture is the means of obtaining for human use a natural product which is abundant in almost all parts of the country, and which would be lost to us were it not for the honey bee. The annual production of honey and wax in the United States makes apiculture a profitable minor industry of the country. From its very nature it can never become one of the leading agricultural pursuits, but that there is abundant opportunity for its growth can not be doubted. Not only is the honey bee valuable as a producer, but it is also one of the most beneficial of insects in cross-pollinating the flowers of various economic plants.

Bee keeping is also extremely fascinating to the majority of people as a pastime, furnishing outdoor exercise as well as intimacy

* See page 555 for illustration.

with an insect whose activity has been a subject of absorbing study from the earliest times. It has the advantage of being a recreation which pays its own way and often produces no mean profit.

It is a mistake, however, to paint only the bright side of the picture and leave it to the new bee keeper to discover that there is often another side. Where any financial profit is derived, bee keeping requires hard work and work at just the proper time, otherwise the surplus of honey may be diminished or lost. Few lines of work require more study to insure success. In years when the available nectar is limited, surplus honey is secured only by judicious manipulations and it is only through considerable experience and often by expensive reverses that the bee keeper is able to manipulate properly to save his crop. Anyone can produce honey in seasons of plenty, but these do not come every year in most locations and it takes a good bee keeper to make the most of poor years. When, even with the best of manipulations, the crop is a failure through lack of nectar, the bees must be fed to keep them from starvation.

Location of the Apiary.—The location of the hives is a matter of considerable importance. As a rule it is better for hives to face away from the prevailing wind and to be protected from high winds. In the North, a south slope is desirable. It is advisable for hives to be so placed that the sun will strike them early in the morning, so that the bees become active early in the day, and thus gain an advantage by getting the first supply of nectar. It is also advantageous to have the hives shaded during the hottest part of the day, so that the bees will not hang out in front of the hive instead of working. They should be so placed that the bees will not prove a nuisance to passers-by or disturb livestock. This latter precaution may save the bee keeper considerable trouble, for bees sometimes prove dangerous, especially to horses.

The plot on which the hives are placed should be kept free from weeds, especially in front of the entrances. The hives should be far enough apart to permit of free manipulation. If hives are too close together there is danger of bees entering the wrong hive on returning, especially in the spring.

These conditions, which may be considered as ideal, need not all be followed. When necessary bees may be kept on house tops, in the back part of city lots, in the woods, or in many other places where the ideal conditions are not found. As a matter of fact, few apiaries are perfectly located; nevertheless, the location should be carefully planned, especially when a large number of colonies are kept primarily for profit.

As a rule, it is not considered best to keep more than 100 colonies in one apiary, and apiaries should be at least 2 miles apart. There are so many factors to be considered, however, that no general rule can be laid down. The only way to learn how many colonies any given locality will sustain is to study the honey flora and the record of that place until the bee keeper can decide for himself the best number to be kept and where they shall be placed.

Out apiaries, or those located away from the main apiary, should be so located that transportation will be as easy as possible. The primary consideration, however, must be the available nectar supply and the number of colonies of bees already near enough to draw on the resources. The out apiary should also be near to some friendly person, so that it may be protected against depredation and so that the owner may be notified if anything goes wrong. It is especially desirable to have it in the partial care of some person who can hive swarms or do other similar things that may arise in an emergency. The terms under which the apiary is placed on land belonging to some one else is a matter for mutual agreement. There is no general usage in this regard.

Equipment in Apparatus.—It must be insisted that the only profitable way to keep bees is in hives with movable frames. The bees build their combs in these frames, which can then be manipulated by the bee keeper as necessary. The keeping of bees in boxes, hollow logs, or straw "skeps" is not profitable, is often a menace to progressive bee keepers, and should be strongly condemned. Bees in box hives (plain boxes with no frames and with combs built at the will of the bees) are too often seen in all parts of the country. The owners may obtain from them a few pounds of inferior honey a year and carelessly continue in the antiquated practice. In some cases this type of bee keeping does little harm to others, but where diseases of the brood are present the box hive is a serious nuisance and should be abolished.

Hives.—The type of hive most generally used in this country was invented by Langstroth in 1851. It consists of a plain wooden box holding frames hung from a rabbet at the top and not touching the sides, top, or bottom. Hives of this type are made to hold from eight frames upward. The size of frame in general use, known as the Langstroth (or L) frame (9⅛ by 17⅝ inches), is more widely used than all others combined. The number of frames used depends on the kind of honey produced (whether comb or extracted), and on the length of honey flow and other local factors. There are other hives used which have points of superiority. These will be found discussed in the various books on bee keeping and in the catalogues of dealers in bee keepers' supplies.

Whatever hive is chosen, there are certain points of importance which should be insisted on. The material should be of the best; the parts must be accurately made, so that all frames or hives in the apiary are inter-changeable. All hives should be of the same style and size; they should be as simple as it is possible to make them to facilitate operation. Simple frames diminish the amount of propolis, which will interfere with manipulation. As a rule, it is better to buy hives and frames from a manufacturer of such goods rather than to try to make them, unless one is a good wood worker.

Hive Stands.—Generally it is best to have each hive on a separate stand. The entrance should be lower than any other part of the hive. Stands of wood, bricks, tile, concrete blocks, or any other convenient material will answer the purpose. The hive should be raised above the ground so that the bottom will not rot. It is usually not necessary to raise the hive more than a few inches. Where ants are a nuisance special hive stands are sometimes necessary.

Other Apparatus.—In addition to the hives in which the bees are kept some other apparatus is necessary. A good smoker, consisting of a tin or copper receptacle to hold burning rotten wood or other material, with a bellows attached, is indispensable. A veil of black material, preferably with a silk tulle front, should be used. Wirecloth veils are also excellent. Even if a veil is not always used, it is desirable to have one at hand in case the bees become cross. Cloth or leather gloves are sometimes used to protect the hands, but they hinder most manipulations. Some sort of tool to pry hive covers loose and frames apart is desirable. A screw-driver will answer, but any of the tools made especially for that purpose is perhaps better. Division boards, drone traps, bee escapes, feeders, foundation fasteners, wax extractors, bee brushes, queen-rearing outfits, and apparatus for producing comb, or extracted honey will be found described in catalogues of supplies; a full discussion of these implements would require too much space in this bulletin.

Equipment in Bees.—As stated previously, it is desirable to begin bee keeping with a small number of colonies. In purchasing these, it is usually best to obtain them near at home rather than to send to a distance, for there is considerable liability of loss in shipment. Whenever possible, it will be better to get bees already domiciled in the particular hive chosen by the bee keeper as the best, but if this is not practicable then bees in any hives or in box hives may be purchased and transferred.

A most important consideration in purchasing colonies of bees is to see to it that they are free from disease. In many States and counties there are inspectors of apiaries who can be consulted on this point, but if this is not possible even a novice can tell whether or not there is anything wrong with the brood, and it is always safest to refuse hives containing dead brood.

The best time of the year to begin bee keeping is in the spring, for during the first few months of ownership the bee keeper can study the subject and learn what to do, so that he is not so likely to make a mistake which will end in loss of bees. It is usually best to buy good strong colonies with plenty of brood for that season of the year, but if this is not practicable, then smaller colonies, or nuclei, may be purchased and built up during the season. Of course, no surplus honey can be expected if all the honey gathered goes into the making of the additional bees. It is desirable to get as little drone comb as possible and a good supply of honey in the colonies purchased.

The question as to what race and strain of bees is to be kept is important. If poor stock has been purchased locally, the bee keeper should send to some reliable queen breeder for good queens as a foundation for his apiary. Queens may be purchased for $1 each for "untested" to several dollars each for "selected" breeding queens. Usually it will not pay beginners to buy "selected" breeding queens, for they are not yet prepared to make the best use of such stock. Untested or tested queens are usually as good a quality as are profitable for a year or so, and there is also less danger in mailing untested (young) queens. Various races of bees have been imported into the United States and among experienced bee keepers there are ardent advocates of almost all of them.

The Italian bees are the most popular race among the best bee keepers in this country. They are vigorous workers and good honey gatherers, defend their hives well, and above all have been more carefully selected by American breeders than any other race. Especially for the last reason it is usually desirable to keep this race. That almost any other race of bees known could be bred to as high a point as the Italians, and perhaps higher, can not be doubted, but the bee keeper now gets the benefit of what has been done for this race. It should not be understood from this that the efforts at breeding have been highly successful. On the contrary, bee breeding will compare very unfavorably with the improvement of other animals or plants which have been the subject of breeding investigations.

Some breeders have claimed to select Italians for greater length of tongue, with the object of getting a bee which could obtain the abundance of nectar from red clover. If any gain is ever made in this respect it is soon lost. The terms "red-clover bees" or "long-tongued bees" are somewhat misleading, but are ordinarily used as indicating good honey producers.

Bee Behavior.—A colony of bees consists normally of one queen bee, the mother of the colony, and thousands of sexually undeveloped females called workers, which normally lay no eggs, but gather the stores, keep the hive clean, feed the young, and do the other work of the hive. During part of the year there are also present some hundreds of males or drones (often removed or restricted in numbers by the bee keeper) whose only service is to mate with young queens. These three types are easily recognized, even by a novice. In nature the colony lives in a hollow tree or other cavity, but under manipulation thrives in the artificial hives provided. The combs which form their abode are composed of wax secreted by the workers. The hexagonal cells of the two vertical layers constituting each comb have interplaced ends on a common septum. In the cells of these combs are reared the developing bees, and here are stored honey and pollen for food.

The cells built naturally are not all of the same size, those used in rearing worker bees being about one-fifth of an inch across, and those used in rearing drones and in storing honey about one-fourth of an inch across. The storage cells are more irregular, and generally curve upward at the outer end. Under manipulation, the size of the cells is controlled by the bee keeper by the use of comb foundation—sheets of pure beeswax on which are impressed the bases of cells and on which the bees build the side walls.

In the North, when the activity of the spring begins, the normal colony consists of the queen and some thousands of workers. As the workers bring in early pollen and honey, the queen begins to lay eggs in the worker cells. These in time develop into white larvæ, which grow to fill the cells. They are then capped over and transform gradually into adult worker bees. As the weather grows warmer, and the colony increases in size by the emergence of the developing bees, the quantity of brood is increased. The workers continue to bring in pollen, and nectar to be made into honey. After a time the queen begins to lay eggs in the larger cells, and these develop into drones or males.

Continued increase of the colony would result in the formation of enormous colonies, and unless some division takes place no increase in the number of colonies will result. Finally, however, the workers begin to build queen cells over certain female larvæ. These are larger than any other cells in the hive and hang on the comb vertically. In size and shape they may be likened to a peanut and are also rough on the outside. When the larvæ in these cells have grown to full size they too are sealed up, and the colony is then ready for swarming.

Swarming consists of the exit from the hive of the original queen with part of the workers. They leave the hive to seek a new home and begin the building of combs, storing of honey and pollen, and rearing of brood in a new location. They leave behind the honey stores, except such as they can carry in their honey stomachs, and the brood, some workers, and no adult queen, but several queen cells from which will later emerge young queens. By this interesting process the original colony is divided into two.

The swarm finds a new location either in a hollow tree or, if cared for by the bee keeper, in a hive. The workers build new combs, the queen begins laying, and in a short time the colony is again in normal condition.

The colony on the old stand (parent colony) has the advantage of the bees which emerge from the brood. After a time (usually about nine days), the queens in their cells are ready to emerge. If the colony is only moderately strong the first queen to emerge is allowed by the workers to tear down the other queen cells and kill the queens not yet emerged, but if a second swarm is to be given off the queen cells are protected.

If the weather permits, after from five to eight days the young queen flies from the hive to mate with a drone. Mating usually occurs but once during the life of the queen and always takes place on the wing. In this single mating she receives enough spermatozoa to last throughout her life. She returns to the hive after mating, and in about two days begins egg laying. The queen never leaves the hive except at mating time or with a swarm, and her sole duty in the colony is to lay eggs to keep up the population.

When the flowers are in bloom which furnish most nectar, the bees usually gather more honey than they need for their own use, and this the bee keeper can safely remove. They continue the collection of honey and other activities until cold weather comes on in the fall, when brood rearing ceases; they then become relatively quiet, remaining in the hive all winter, except for short flights on warm days. When the main honey flow is over, the drones are usually driven from the hive. By that time the virgin queens have been mated and drones are of no further use. They are not usually stung to death, but are merely carried or driven from the hive by the workers and starve. A colony of bees which for any reason is without a queen does not expel the drones.

Many abnormal conditions may arise in the activity of a colony, and it is therefore necessary for the bee keeper to understand most of these, so that when they occur he may overcome them. If a virgin queen is prevented from mating she generally dies, but occasionally begins to lay eggs after about four weeks. In this event, however, all of the eggs which develop become males. Such a queen is commonly called a drone-layer. If the virgin queen is lost while on her flight or the colony at any other time is left queenless without means of rearing additional queens, it sometimes happens that some of the workers begin to lay eggs. These eggs also develop only into drones. It also happens at times that when a queen becomes old her supply of spermatozoa is exhausted, at which time her eggs also develop only into drones. These facts are the basis of the theory that the drone of the bee is developed from an unfertilized egg.

The work of the hive is very nicely apportioned among the inmates, so that there is little lost effort. As has been stated, the rearing of young is accomplished by having one individual to lay eggs and numerous others (immature females) to care for the larvæ. In like manner all work of the colony is apportioned. In general, it may be stated that all inside work—wax building, care of brood, and cleaning—is done by the younger workers, those less than 17 days old, while the outside work of collecting pollen and nectar to be made into honey is done by the older workers. This plan may be changed by special conditions. For example, if the colony has been queenless for a time and a queen is then given, old workers may begin the inside work of feeding larvæ and these may also secrete wax. Or, if the old workers are all removed, the younger bees may begin outside work. As a rule, however, the general plan of division of labor according to age is followed rather closely.

Directions for General Manipulations.—Bees should be handled so that they will be little disturbed in their work. As much as possible, stings should be avoided during manipulation. This is true not so much because they are painful to the operator, but because the odor of poison which gets into the air irritates the other bees and makes them more difficult to manage. For this reason it is most advisable to wear a black veil over a wide-brimmed hat and to have a good smoker. Experienced bee keepers often dispense with these, but the beginner should not. Gloves, however, are usually more an inconvenience than otherwise. Gauntlets or rubber bands around the cuffs keep the bees from crawling up the sleeve. It is best to avoid black clothing, since that color seems to excite bees; a black felt hat is especially to be avoided.

The bee keeper should manipulate without exhibiting fear. This is not because the bees recognize the fact that the operator is afraid of them, as some claim, but because superfluous quick movements tend to irritate the bees. The hive should not be jarred or disturbed any more than necessary. Rapid movements are objectionable, because with their peculiar eye structure bees probably perceive motion more rapidly than they do objects. Persons not accustomed to bees, on approaching a hive, often strike at bees which fly toward them or make some quick movement of the head or hand to avoid the sting which they fear is to follow. This is just what should not be done, for the rapid movement, even if not toward the bee, is far more likely to be followed by a sting than is remaining quiet.

The best time to handle bees is during the middle of warm days, particularly during a honey flow. Never handle bees at night or on cold, wet days unless absolutely necessary.

Before opening a hive the smoker should be lighted and the veil put on. A few puffs of smoke directed into the entrance will cause the bees to fill themselves with honey and will drive back the guards. The hive cover should be raised gently, if necessary being pried loose with a screw-driver or special hive tool. As soon as a small opening is made, more smoke should be blown in on the tops of the frames, or if a mat covering for the frames is used, the cover should be entirely removed and one corner of the mat lifted to admit smoke. It is not desirable to use any more smoke than just enough to subdue the bees and keep them down on the frames. At any time during manipulation, if they become excited, more smoke may be used. Do not stand in front of the entrance, but at one side or the back.

After the frames are exposed they may be loosened by prying with the hive tool and crowded together a little so as to give room for the removal of one frame. In cool weather the propolis (bee glue) may be brittle. Care should be exercised not to loosen this with a jar. The first frame removed can be leaned against the hive, so that inside there will be more room for handling the others. During all manipulations bees must not be mashed or crowded, for that irritates the colony greatly and may make it necessary to discontinue operations. Undue crowding may also mash the queen. If bees crawl on the hands, they may be gently brushed off or thrown off.

In examining a frame always hold it over the hive, so that any bees or queen which fall may drop into it. Freshly gathered honey also often drops from the frame, and if it falls in the hive the bees can quickly clean it up, whereas if it drops outside it is untidy and may cause robbing. If a frame is temporarily leaned against the hive, it should be placed in a nearly upright position to prevent breakage and leaking of honey. The frame on which the queen is located should not be placed on the ground, for fear she may crawl away and be lost. It is best to lean the frame on the side of the hive away from the operator, so that bees will not crawl up the legs.

In handling frames the comb should always be held in a vertical position, especially if it contains much money. When a frame is lifted from the hive by the top bar, one side is exposed to the operator with the comb placed vertically. To examine the reverse side, raise one end of the top bar until it is perpendicular, turn the frame on the top bars as an axis until the reverse side is in view, and then lower to a horizontal position with the top bar below. In this way there is no extra strain on the comb and the bees are not irritated. This care is not so necessary with wired combs, but it is a good habit to form in handling frames.

It is desirable to have combs all of worker cells to reduce the amount of drone brood. The use of full sheets of foundation will bring this about and is also of value in making the combs straight, so that bees are not mashed in removing the frame. It is extremely difficult to remove combs built crosswise in the hive, and this should never be allowed to occur. Such a hive is even worse than a plain box hive. Extra inside fixtures should be avoided, as they tend only to impede manipulation. The hive should also be placed so that the entrance is perfectly horizontal and a little lower than the back of the hive. The frames will then hang in a vertical position, and the outer ones will not be fastened to the hive body if properly spaced at the top.

Various remedies for bee stings have been advocated, but they are all useless. The puncture made by the sting is so small that it closes when the sting is removed and liquids can not be expected to enter. The best thing to do when stung is to remove the sting as soon as possible without squeezing the poison sac, which is usually attached. This can be done by scraping it out with a knife or finger nail. After this is done the injured spot should be let alone and not rubbed with any liniment. The intense itching will soon disappear; any irritation only serves to increase the after swelling.

In placing frames in the hive great care should be exercised that they are properly spaced. Some frames are self-spacing, having projections on the side, so that when placed as close as possible they are the correct distance apart. These are good for beginners or persons who do not judge distances well and are preferred by many professional bee keepers. If unspaced frames are used, they should be 1⅜ inches from center to center. A little practice will usually enable anyone to space quickly and accurately. Careful spacing is necessary to prevent the building of combs of irregular thickness and to retard the building of pieces of comb from one frame to another.

Transferring.—In increasing the apiary it is sometimes best to buy colonies in box hives on account of their smaller cost and to transfer them to hives with movable frames. This should be done as soon as possible, for box-hive colonies are of small value as producers. The best time to transfer is in the spring (during fruit bloom in the North) when the amount of honey and the population of the colony are at a minimum.

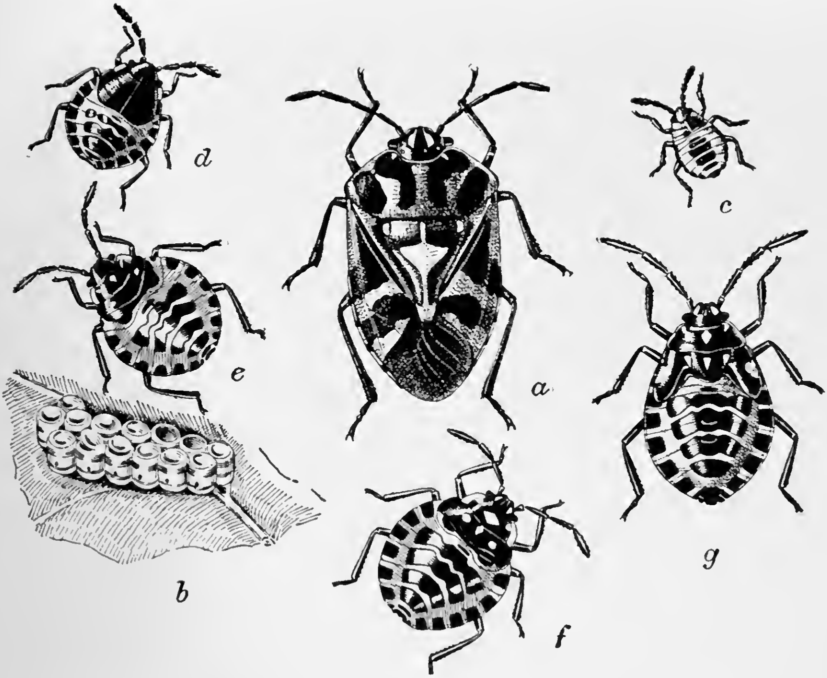
Transferring should not be delayed until spring merely because that season is best for the work. It may be done at any time during the active season, but, whenever possible, during a honey flow, to prevent robbing. If necessary, it may be done in a tent such as is often used in manipulating colonies. By choosing a time of the day when the largest number of bees are in the field the work will be lessened.

The box hive should be moved a few feet from its stand and in its place should be put a hive containing either full sheets of foundation or empty combs. The box hive should be turned upside down and a small, empty box fitted on it. By drumming continuously on the box hive for a considerable time the bees will be made to desert their combs and go to the upper box, and when most of them are clustered above the box may be carried to the new hive and the bees dumped in front of the entrance. The queen will usually be seen as the bees enter the hive, but in case she has not left the old combs, more drumming will induce her to leave. It is necessary that the queen be in the hive before this manipulation is finished. The old box hive containing brood may now be placed right side up in a new location and in twenty-one days all of the worker brood will have emerged and probably some new queens will have been reared. These bees may then be drummed out and united with their former hive mates by smoking the colony and the drummed bees vigorously and allowing the latter to enter the hive through a perforated zinc to keep out the young queens. The wax in the box hive may then be melted up and any honey which it may contain used as the bee keeper sees fit. By this method good straight combs are obtained. If little honey is being gathered, the colony in the hive must be provided with food.

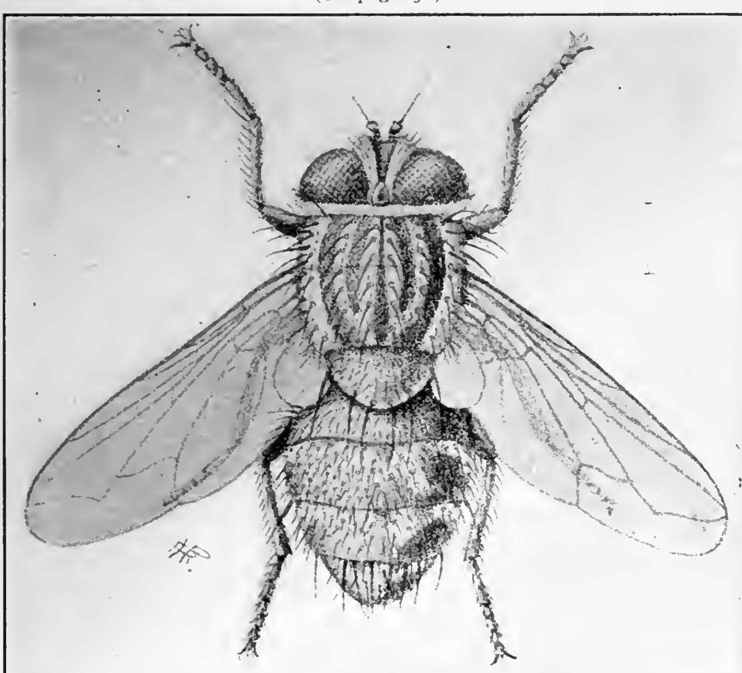
If, on the other hand, the operator desires to save the combs of the box hive, the bees may be drummed into a box and the brood combs and other fairly good combs cut to fit frames and tied in place or held with rubber bands, strings, or strips of wood until the bees can repair the damage and fill up the breaks. These frames can then be hung in a hive on the old stand and the bees allowed to go in. The cutting of combs containing brood with more or less bees on them is a disagreeable job, and, since the combs so obtained are usually of little value in an apiary, the first method is recommended.

Colonies often take up their abode in walls of houses and it is often necessary to remove them to prevent damage from melting combs. If the cavity in which the combs are built can be reached, the method of procedure is like that of transferring, except that drumming is impractical and the bees must simply be subdued with smoke and the combs cut out with the bees on them.

Another method which is often better is to place a bee escape over the entrance to the cavity, so that the bees can come out, but can not return. A cone of wire cloth about 8 inches high with a hole at the apex just large enough for one bee to pass will serve as a bee escape, or a regular bee escape such as are sold by dealers may be used. A hive which they can enter is then placed beside the entrance,



HARLEQUIN CABBAGE BUG. DEPT. OF AGR.
(See page 152.)



POTATO BEETLE PARASITE (PHOROCERA DORYPHORAE) ORIGINAL.
R. H. PETIT, MICH. AGR. COLLEGE.

The queen is not obtained in this way and, of course, goes right on laying eggs, but as the colony is rapidly reduced in size the amount of brood decreases. As brood emerges, the younger bees leave the cavity and join the bees in the hive until finally the queen is left practically alone. A new queen should be given to the bees in the hive as soon as possible, and in a short time they are fully established in their new quarters. After about four weeks, when all or nearly all of the brood in the cavity has emerged, the bee escape should be removed and as large a hole made at the entrance of the cavity as possible. The bees will then go in and rob out the honey and carry it to the hive, leaving only empty combs. The empty combs will probably do no damage, as moths usually soon destroy them and they may be left in the cavity and the old entrance carefully closed to prevent another swarm from taking up quarters there.

In transferring bees from a hollow tree the method will depend on the accessibility of the cavity. Usually it is difficult to drum out the bees and the combs can be cut out after subduing the colony with smoke.

Uniting.—Frequently colonies become queenless when it is not practicable to give them a new queen, and the best practice under such conditions is to unite the queenless bees to a normal colony. If any colonies are weak in the fall, even if they have a queen, safe wintering is better insured if two or more weak colonies are united, keeping the best queen. Under various other conditions which may arise the bee keeper may find it desirable to unite bees from different colonies. Some fundamental facts in bee behavior must be thoroughly understood to make this a success.

Every colony of bees has a distinctive colony odor and by this means bees recognize the entering of their hive by bees from other colonies and usually resent it. If, however, a bee comes heavily laden from the field and flies directly into the wrong hive without hesitation it is rarely molested. In uniting colonies, the separate colony odors must be hidden, and this is done by smoking each colony vigorously. It may at times be desirable to use tobacco smoke, which not only covers the colony odor but stupefies the bees somewhat. Care should be taken not to use too much tobacco, as it will completely overcome the bees. The queen to be saved should be caged for a day or two to prevent the strange bees from killing her in the first excitement.

Another fact which must be considered is that the bees of a colony carefully mark the location of their own hive and remember that location for some time after they are removed. If, therefore, two colonies in the apiary which are not close together are to be united, they should be moved gradually nearer, not more than a foot at a time, until they are side by side, so that the bees will not return to their original locations and be lost. As the hives are moved gradually the slight changes are noted and no such loss occurs. As a further precaution, a board should be placed in front of the entrance in a slanting position, or brush and weeds may be thrown down so that when the bees fly out they recognize the fact that there has been a change and accustom themselves to the new place. If uniting can be done during a honey flow, there is less danger of loss of bees by fighting, or if done in cool weather, when the bees are not actively rearing brood, the colony odors are diminished and the danger is reduced.

It is an easy matter to unite two or more weak swarms to make one strong one, for during swarming the bees have lost their memory of the old location, are full of honey, and are easily placed wherever the bee keeper wishes. They may simply be thrown together in front of a hive. Swarms may also be given to a newly established colony with little difficulty.

Feeding.—During spring manipulations, in preparing bees for winter, and at other times it may be necessary to feed bees for stimulation or to provide stores. *Honey from an unknown source should never be used,* for fear of introducing disease, and sirup made of granulated sugar is cheapest and best for this purpose. The cheaper grades of sugar or molasses should never be used for winter stores. The proportion of sugar to water depends on the season and the purpose of the feeding. For stimulation a proportion of one-fourth to one-third sugar by volume is enough, and for fall feeding, especially if rather late, a solution containing as much sugar as it will hold when cold is best. There seems to be little advantage in boiling the sirup. Tartaric acid in small quantity may be added for the purpose of changing part of the cane sugar to invert sugar, thus retarding granulation. The medication of sirup as a preventive or cure of brood disease is often practiced, but it has not been shown that such a procedure is of any value. If honey is fed, it should be diluted somewhat, the amount of dilution depending on the season. If robbing is likely to occur, feeding should be done in the evening.

Numerous feeders are on the market, adapted for different purposes and methods of manipulation. A simple feeder can be made of a tin pan filled with excelsior or shavings. This is filled with sirup and placed on top of the frames in a super or hive body. It is advisable to lean pieces of wood on the pan as runways for the bees, and to attract them first to the sirup, either by mixing in a little honey or by spilling a little sirup over the frames and sticks.

It may be stated positively that it does not pay financially, or in any other way, to feed sugar sirup to be stored in sections and sold as comb honey. Of course, such things have been tried, but the consumption of sugar during the storing makes the cost greater than the value of pure floral honey.

Spring Management.—The condition of a colony of bees in the early spring depends largely on care in the preceding autumn and in the method of wintering. If the colony has wintered well and has a good prolific queen, preferably young, the chances are that it will become strong in time to store a good surplus when the honey flow comes.

The bees which come through the winter, reared the previous autumn, are old and incapable of much work. As the season opens they go out to collect the early nectar and pollen, and also care for the brood which hatches from the eggs laid by the queen. The amount of brood is at first small, and as the new workers emerge they assist in the brood rearing so that the extent of the brood can be gradually increased until it reaches the maximum at the beginning of the summer. The old bees die off rapidly.

If brood rearing does not continue late in the fall so that the colony goes into winter with a large percentage of young bees, the old bees may die off in the spring faster than they are replaced by emerging brood. This is known as spring dwindling. A remedy for this may be applied by feeding, if necessary, the autumn before, or keeping up brood rearing by some other means as late as possible.

If spring dwindling begins, however, it can be diminished somewhat by keeping the colony warm and by stimulative feeding, so that all the energy of the old bees may be put to the best advantage in rearing brood to replace those dying off. The size of the brood chamber can also be reduced to conserve heat.

Bees should not be handled in the early spring any more than necessary, for to open a hive in cool weather wastes heat and may even kill the brood by chilling. The hive should be kept as warm as possible in early spring as an aid to brood rearing. It is a good practice to wrap hives in black tar paper in the spring, not only that it may aid in conserving the heat of the colony, but in holding the sun's heat rays as a help to the warmth of the hive. This wrapping should be put on as soon as an early examination has shown the colony to be in good condition, and there need be no hurry in taking it off. A black wrapping during the winter is not desirable, as it might induce brood rearing too early and waste the strength of the bees.

As a further stimulus to brood rearing, many bee keepers practice stimulative feeding of sugar sirup in early spring. This produces the same effect as a light honey flow does and the results are good. Others prefer to give the bees such a large supply of stores in the fall that when spring comes they will have an abundance for brood rearing, and it will not be necessary to disturb them in cool weather. Both ideas are good, but judicious stimulative feeding usually more than pays for the labor. Colonies should be fed late in the day, so that the bees will not fly as a result of it, and so that robbing will not be started. When the weather is warmer and more settled, the brood cluster may be artificially enlarged by spreading the frames so as to insert an empty comb in the middle. The bees will attempt to cover all the brood that they already had, and the queen will at once begin laying in the newly inserted comb, thus making a great increase in the brood. This practice is desirable when carefully done, but may lead to serious results if too much new brood is produced. A beginner had better leave the quantity of brood to the bees.

It is desirable early in the season, before any preparations are made for swarming, to go through the apiary and clip one wing of each queen so that if a swarm issues the queen can not fly and the bees can be easily returned to the old stand. This should be done before the hive becomes too populous. It is perhaps best to clip queens as they are introduced, but some colonies may rear new ones without the knowledge of the owner, and a spring examination will insure no escaping swarms.

Queens sometimes die during the winter and early spring, and since there is no brood from which the bees can replace them, the queenless colonies are hopelessly queenless. Such colonies are usually restless and are not active in pollen gathering. If, on opening a colony, it is found to be without a queen and reduced in numbers, it should be united with another colony by smoking both vigorously and caging the queen in the queen-right colony for a day or two to prevent her being killed. A frame or two of brood may be added to a queenless colony, not only to increase its strength, but to provide young brood from which they can rear a queen. Bee keepers in the North can frequently buy queens from southern breeders early in the spring, and naturally this is better than leaving the colony without a queen until the bees can rear one, as it is important that there be no stoppage in brood rearing at this season.

Swarm Management and Increase.—The excessive rearing of brood at the wrong season or increase in the number of colonies greatly reduces the surplus honey crop by consumption. The ideal to which all progressive bee keepers work, when operating simply for honey, is to stimulate brood rearing to prepare bees for gathering, to retard breeding when it is less desirable, and to prevent swarming. Formerly the measure of success in bee keeping was the amount of increase by swarming, but this is now recognized as being quite the contrary of success.

The stimulation of brood rearing in the spring, however, makes it more likely that swarming will occur; so that the operator must counteract that tendency. This is especially true in comb-honey production. Very few succeed in entirely preventing swarming, but by various methods the situation can be largely controlled.

When a swarm issues, it usually first settles on a limb of a tree or bush near the apiary. It was formerly common to make a noise by beating pans or ringing bells in the belief that this causes the swarm to settle. There is no foundation for such action on the part of the bee keeper. If the bees light on a small limb that can be spared, it may simply be sawed off and the bees carried to the hive and thrown on a sheet or hive cover in front of the entrance. If the limb can not be cut, the swarm can be shaken off into a box or basket on a pole and hived. If the bees light on the trunk of a tree or in some inaccessible place, they can first be attracted away by a comb, preferably containing unsealed brood. In these manipulations it is not necessary to get all the bees, but if the queen is not with those which are put in the hive the bees will go into the air again and join the cluster.

If a queen is clipped as recommended under "Spring Management," the swarm will issue just the same, but the queen, not being able to fly, will simply wander about on the ground in front of the hive, where she can be caught and caged. The parent colony can then be removed to a new stand and a new hive put in its place. The bees will soon return and the queen can be freed among them as they enter. The field bees on returning will enter the new hive with the swarm, thus decreasing still more the parent colony and making a second swarm less probable. To make sure of this, however, all queen cells except one good one can be removed soon after the swarm issues. To hold a swarm it is desirable to put one frame containing unsealed brood in the new hive. The other frames may contain full sheets or starters of foundation or drawn combs. Usually comb-honey supers or surplus bodies for extracting frames will have been put on before swarming occurs. These are given to the swarm on the old stand and separated from the brood chamber by queen-excluding perforated zinc.

When clipping the queens' wing is not practiced, swarms may be prevented from leaving by the use of queen traps of perforated zinc. These allow the workers to pass out, but not drones or queens, which, on leaving the entrance, pass up to an upper compartment from which they can not return. These are also used for keeping undesirable drones from escaping, and the drones die of starvation. When a swarm issues from a hive provided with a queen trap, the queen goes to the upper compartment and remains there until released by the bee keeper. The workers soon return to the hive. When the operator discovers the queen outside, the colony may be artificially swarmed to prevent another attempt at natural swarming. A queen trap should not be kept on the hive all the time for fear the old queen may be superseded and the young queen prevented from flying out to mate.

Prevention of Swarming.—Unless increase is particularly desired, both natural and artificial swarming should be done away with as far as possible, so that the energy of the bees shall go into the gathering of honey. Since crowded and overheated hives are particularly conducive to swarming, this tendency may be largely overcome by giving plenty of ventilation and additional room in the hive. Shade is also a good preventive of swarming. Extra space in the hive may be furnished by adding more hive bodies and frames or by frequent extracting, so that there may be plenty of room for brood rearing and storage at all times. These manipulations are, of course, particularly applicable to extracted-honey production.

To curb the swarming impulse frequent examinations of the colonies (about every week or ten days during the swarming season) for the purpose of cutting out queen cells is a help, but this requires considerable work, and since some cells may be overlooked, and particularly since it frequently fails in spite of the greatest care, it is not usually practiced. Requeening with young queens early in the season, when possible, generally prevents swarming.

Swarming is largely due to crowded brood chambers, and since eggs laid immediately before and during the honey flow do not produce gatherers, several methods have been tried of reducing the brood. The queen may either be entirely removed or be caged in the hive to prevent her from laying. In either event the bees will usually build queen cells to replace her, and these must be kept cut out. These plans would answer the purpose very well were it not for the fact that queenless colonies often do not work vigorously. Under most circumstances these methods can not be recommended. A better method is to remove brood about swarming time and thus reduce the amount. There are generally colonies in the apiary to which frames of brood can be given to advantage.

In addition to these methods various nonswarming devices have been invented, and later a nonswarming hive so constructed that there is no opportunity for the bees to form a dense cluster. The breeding of bees by selecting colonies with less tendency to swarm has been suggested, but nothing has been accomplished along that line.

On the whole, the best methods are the giving of plenty of room, shade, and ventilation to colonies run for extracted honey; and ventilation, shade, and artificial swarming of colonies run for comb honey. Frequent requeening (about once in two years) is desirable for other reasons, and requeening before swarming time helps in the solution of that difficulty.

Preparation for the Harvest.—An essential in honey production is to have the hive overflowing with bees at the beginning of the honey flow, so that the field force will be large enough to gather more honey than the bees need for their own use. To accomplish this, the bee keeper must see to it that brood rearing is heavy some time before the harvest, and he must know accurately when the honey flows come, so that he may time his manipulations properly. Brood rearing during the honey flow usually produces bees which consume stores, while brood reared before the flow furnishes the surplus gatherers. The best methods of procedure may be illustrated by giving as an example the conditions in the white-clover region.

In the spring the bees gather pollen and nectar from various early flowers, and often a considerable quantity from fruit bloom and dandelions. During this time brood rearing is stimulated by the new honey, but afterwards there is usually a period of drought when brood rearing is normally diminished or not still more increased as it should be. This condition continues until the white-clover flow comes on, usually with a rush, when brood rearing is again augmented. If such a condition exists, the bee keeper should keep brood rearing at a maximum by stimulative feeding during the drought. When white clover comes in bloom he may even find it desirable to prevent brood rearing to turn the attention of his bees to gathering.

A worker bee emerges from its cell twenty-one days after the egg is laid, and it usually begins field work in from fourteen to seventeen days later. It is evident, therefore, that an egg must be laid five weeks before the honey flow to produce a gatherer. Since the flow continues for some time and since bees often go to the field earlier than fourteen days, egg laying should be pushed up to within two or three weeks of the opening of the honey flow. In addition to stimulative feeding, the care of the colony described under the heading of Spring Management will increase brood production.

The Production of Honey.—The obtaining of honey from bees is generally the primary object of their culture. Bees gather nectar to make into honey for their own use as food, but generally store more than they need, and this surplus the bee keeper takes away. By managing colonies early in the spring as previously described, the surplus may be considerably increased. The secret of maximum crops is to keep all colonies strong.

Honey is gathered in the form of nectar secreted by various flowers, transformed by the bees, and stored in the comb. Bees also often gather a sweet liquid called honeydew, produced by various scale insects and plant-lice, but the honeydew honey made from it is quite unlike floral honey and should not be sold for honey. It is usually unpalatable and should never be used as winter food for bees. When nectar or honeydew has been thickened by evaporation and otherwise changed, the honey is sealed in the cells with cappings of beeswax.

It is not profitable to cultivate any plant solely for the nectar which it will produce, but various plants, such as clovers, alfalfa, and buckwheat are excellent honey plants as well as valuable for other purposes; their cultivation is therefore a benefit to the bee keeper. It is often profitable to sow some plant on waste land; sweet clovers are often used in this way. The majority of honey-producing plants are wild, and the bee keeper must largely accept the locality as he finds it and manage his apiary so as to get the largest possible amount of the available nectar. Since bees often fly as far as 2 or 3 miles to obtain nectar, it is obvious that the bee keeper can rarely influence the nectar supply appreciably.

Extracted Honey.—Extracted honey is honey which has been removed by means of centrifugal force from the combs in which the bees stored it. In providing combs for the storage of honey to be extracted, the usual practice is to add to the top of the brood chamber one or more hive bodies just like the one in which the brood is reared and fill these with frames. If preferred, shallower frames with bodies of proper size may be used, but most honey extractors are made for full-size frames. The surplus bodies should be put on in plenty of time to prevent the crowding of the brood chamber, and also to act as a preventive of swarming.

Honey for extracting should not be removed until it is well ripened and a large percentage of it capped. It is best, however, to remove the crop from each honey flow before another heavy producing plant comes into bloom, so that the different grades of honey may be kept separate.

The frames containing honey to be extracted are removed from the hive, the cappings cut off with a sharp, warm knife, made specially for this purpose, and the frames are then put into the baskets of the honey extractors. By revolving these rapidly the honey is thrown out of one side. The basket is then reversed and the honey from the other side is removed. The combs can then be returned to the bees to be refilled, or if the honey flow is over, they can be returned to the bees to be cleaned and then removed and stored until needed again. This method is much to be preferred to mashing the comb and straining out the honey, as was formerly done.

The extracted honey is then strained and run into vessels. It is advisable not to put it in bottles at once, but to let it settle in open vessels for a time, so that it can be skimmed. Most honeys will granulate and become quite hard if exposed to changes of temperature, and to liquefy granulated extracted honey it should be heated in a water bath. Never heat honey directly over a stove or flame, as the flavor is thereby injured. The honey should never be heated higher than 160° F. unless it is necessary to sterilize it because of contamination of disease.

Extracted honey is put up in bottles or small tin cans for the retail trade, and in 5-gallon square tin cans or barrels for the wholesale market. Great care must be exercised if barrels are used, as honey will absorb moisture from the wood, if any is present, and cause leakage. The tin package is much to be preferred in most cases. In bottling honey for retail trade, it will well repay the bee keeper or bottler to go to considerable expense and trouble to make an attractive package, as the increased price obtained will more than make it up. Honey should be heated to 160° F. and kept there for a time before bottling and the bottle should be filled as full as possible and sealed hermetically.

Comb Honey.—Comb honey is honey as stored in the comb by the bees, the size and shape being determined by the small wooden sections provided by the bee keeper. Instead of having comb in large frames in which to store surplus honey, the bees are compelled to build comb in the sections and to store honey there. A full section weighs about 1 pound; larger ones are rarely used. By the use of modern sections and foundation the comb honey now produced is a truly beautiful, very uniform product—so uniform in fact that it is often charged that it must be artificially manufactured. The purchaser of a section of comb honey may be absolutely certain, however, that he is obtaining a product of the bees, for never has anyone been able to imitate their work successfully. To show their confidence in the purity of a comb honey, the National Bee Keepers' Association offers $1,000 for a single pound of artificial comb filled with an artificially prepared sirup.

There are several different styles of sections now in use, the usual sizes being 4¼ inches square and 4 inches by 5 inches. There are also two methods of spacing, so that there will be room for the passage of bees from the brood chamber into the sections and from one super of sections to another. This is done either by cutting bee ways in the sides of the sections and using plain flat separators or by using no bee-way or plain sections and using fences—separators with cleats fastened on each side to provide the bee space. To describe all the different supers or bodies for holding sections would be impossible in a bulletin of this size, and the reader must be referred to catalogues of dealers in bee-keeping supplies. Instead of using regular comb-honey supers, some bee keepers use wide frames to hold two tiers of sections. It is better, however, to have the supers smaller, so that the bees may be crowded more to produce full sections. To overcome this difficulty, shallow wide frames holding one tier of sections may be used. The majority of bee keepers find it advisable to use special comb-honey supers.

In producing comb honey it is even more necessary to know the plants which produce surplus honey and just when they come in bloom than it is in extracted honey production. The colony should be so manipulated that the maximum field force is ready for the beginning of the flow. This requires care in spring management, and above all the prevention of swarming. Supers should be put on just before the heavy flow begins. A good indication of the need of supers is the whitening of the brood cobs at the top. If the bees are in two-hive bodies they should generally be reduced to one, and the frames should be filled with brood and honey so that as the new crop comes in the bees will carry it immediately to the sections. If large hives are used for the brood chamber it is often advisable to remove some of the frames and use a division board to crowd the bees above. To prevent the queen from going into the sections to lay, a sheet of perforated zinc may be put between the brood chamber and the super.

It is often difficult to get bees to begin work in the small sections, but this should be brought about as soon as possible to prevent loss of honey. If there are at hand some sections which have been partly drawn the previous year, these may be put in the super with the new sections as bait. Another good plan is to put a shallow extracting frame on either side of the sections. If a few colonies in the apiary that are strong enough to go above still refuse, lift supers from some colonies that have started to work above and give them to the slow colonies. The super should generally be shaded somewhat to keep it from getting too hot. Artificial swarming will quickly force bees into the supers.

To produce the finest quality of comb honey full sheets of foundation should be used in the section. Some bee keepers use nearly a full sheet hung from the top of the section and a narrow bottom starter. The use of foundation of worker-cell size is much preferred.

When one super becomes half full or more and there are indications that there will be honey enough to fill others, the first one should be raised and an empty one put on the hive under it. This tiering up can be continued as long as necessary, but it is advisable to remove filled sections as soon as possible after they are nicely capped, for they soon become discolored and less attractive. Honey removed immediately after capping finds a better market, but if left on the hive even until the end of the summer the quality of the honey is improved. A careful watch must be kept on the honey flow, so as to give the bees only enough sections to store the crop. If this is not done a lot of unfinished sections will be left at the end of the flow. Honeys from different sources should never be mixed in the sections, as it gives the comb a bad appearance. To remove bees from sections, the super may be put over a bee escape so that the bees can pass down but can not return, or the supers may be removed and covered with a wire-cloth-cone bee escape.

After sections are removed the wood should be scraped free of propolis (bee glue) and then packed in shipping cases for the market. Shipping cases to hold 12, 24, or 48 sections, in which the various styles of sections fit exactly, are manufactured by dealers in supplies. In shipping these cases, several of them should be put in a box or crate packed in straw and paper and handles provided to reduce the chances of breakage. When loaded in a freight car the combs should be parallel with the length of the car.

In preparing comb honey for market it should be carefully graded, so that the sections in each shipping case are as uniform as possible. Nothing will more likely cause wholesale purchasers to cut the price than to find the first row of sections in a case fancy and those behind of inferior grade.

The Production of Wax.—Beeswax, which is secreted by the bees and used by them for building their combs, is an important commercial product. There are times in almost every apiary when there are combs to be melted up, and it pays to take care of even scraps of comb and the cappings taken off in extracting. A common method of taking out the wax is to melt the combs in a solar wax extractor. This is perhaps the most feasible method where little wax is produced, but considerable wax still remains in old brood combs after such heating. Various wax presses are on the market, or one can be made at home. If much wax is produced, the bee keeper should make a careful study of the methods of wax extraction, as there is usually much wax wasted even after pressing.

Preparations for Wintering.—After the main honey flow is over the management must depend on what may be expected later in the season from minor honey flows. If no crop is to be expected, the colony may well be kept only moderately strong, so that there will not be so many consumers in the hive.

In localities where winters are severe and breeding is suspended for several months great care should be taken that brood-rearing is rather active during the late summer, so that the colony may go into winter with plenty of young bees. In case any queens show lack of vitality they should be replaced early, so that the bees will not become queenless during the winter. The important considerations in wintering are plenty of young bees, a good queen, plenty of stores of good quality, sound hives, and proper protection from cold and dampness.

If, as cold weather approaches, the bees do not have stores enough, they must be fed. Every colony should have from 25 to 50 pounds, depending on the length of winter and the methods of wintering. It is better to have too much honey than not enough, for what is left is good next season. If feeding is practiced, honey may be used, but sirup made of granulated sugar is just as good and is perfectly safe. If honey is purchased for feeding, great care should be taken that it comes from a healthy apiary, otherwise the apiary may be ruined by disease. *Never feed honey bought on the open market.* The bees should be provided with stores early enough so that it will not be necessary to feed or to open the colonies after cold weather comes on. Honeydew honey should not be left in the hives, as it produces dysentery. Some honeys are also not ideal for winter stores. Those which show a high percentage of gums (most tree honeys) are not so desirable, but will usually cause no trouble.

In wintering out of doors the amount of protection depends on the severity of the winter. In the South no packing is necessary, and even in very cold climates good colonies with plenty of stores can often pass the winter with little protection, but packing and protection make it necessary for the bees to generate less heat, and consequently they consume less stores and their vitality is not reduced. Dampness is probably harder for bees to withstand than cold, and when it is considered that bees give off considerable moisture, precautions should be taken that as it condenses it does not get on the cluster. An opening at the top would allow the moisture to pass out, but it would also waste heat, so it is better to put a mat of burlap or other absorbent material on top of the frames. The hive may also be packed in chaff, leaves, or other similar dry material to keep out the cold. Some hives are made with double walls, the space being filled with chaff; these are good for outdoor wintering. The hive entrance should be lower than any other part of the hive, so that any condensed moisture may run out. The hives should be sound and the covers tight and waterproof.

Entrances should be contracted in cold weather not only to keep out cold wind, but to prevent mice from entering. There should always be enough room, however, for bees to pass in and out if warmer weather permits a flight.

In the hands of experienced bee keepers cellar wintering is very successful, but this method requires careful study. The cellar must be dry and so protected that the temperature never varies more than from 40° to 45° F.; 43° F. seems to be the optimum temperature. The ventilation must be good or the bees become fretful. Light should not be admitted to the cellar, and consequently some means of indirect ventilation is necessary.

Cellar wintering requires the consumption of less honey to maintain the proper temperature in the cluster and is therefore economical. Bees so wintered do not have an opportunity for a cleansing flight, often for several months, but the low consumption makes this less necessary. Some bee keepers advocate carrying the colonies out a few times on warm days, but it is not fully established whether this is entirely beneficial and is usually not practiced.

The time for putting colonies in the cellar is a point of dispute, and practice in this regard varies considerably. They should certainly be put in before the weather becomes severe and as soon as they have ceased brood rearing. The time chosen may be at night when they are all in the hive, or on some chilly day.

The hives may be piled one on top of the other, the lower tier raised a little from the floor. The entrances should not be contracted unless the colony is comparatively weak. It is usually not considered good policy to close the entrances with wire cloth, as the dead bees which accumulate more or less on the bottom board may cut off ventilation, and the entrance should be free so that these may be cleaned out.

The time of removing bees from the cellar is less easily determined than that of putting them in. The colonies may be removed early and wrapped in black tar paper or left until the weather is settled. If the weather is very warm and the bees become fretful, the cellar must either be cooled or the bees removed. Some bee keepers prefer to remove bees at night, so that they can recover from the excitement and fly from the hive normally in the morning. One of the chief difficulties is to prevent the bees from getting into the wrong hives after their first flights. They often "drift" badly with the wind, and sometimes an outside row will become abnormally strong, leaving other colonies weak.—(Farmers' Bul. 397, U. S. D. A.)

PART II

DISEASES OF CULTIVATED PLANTS.

INTRODUCTION.

THE idea of disease is not a simple one, though it may seem so before trying to define it. In reality the term disease as applied to plants means any change in that plant toward reduced vigor, etc., from the ordinary or average behavior. To put it another way, a plant is said to be diseased when it shows any deviation from the ordinary or average behavior of that plant in respect to appearance, growth, color of bark, foliage, fruitfulness, time of dropping leaves or length of life; in short, when the plant fails to conform to those averages which we have established by extended observation for the species and variety in question, we say it is diseased. Under such a general definition, variegated or purple hued spots would be included, although potentially rather than actually in diminished vigor. Variegated spots succumb to parasitic attack and, as later investigations show, are really suffering from enzymatic troubles.

The more usual symptoms of disease are marked by evident differences in the plant. The leaves become spotted, curled or discolored, or may even drop prematurely; the fruit may develop unevenly or be marked by decayed spots, or the twigs may blight, wilt or die. In all such cases we have a manifest loss of vigor and reduced profit. Yet we may not attribute all these to parasitic fungi or to parasitic insects; purely physical or chemical agencies may be at the bottom of certain troubles. Plants may be asphyxiated by too much water which excludes the air supply; they may likewise be strangled by escaping gases, especially in the case of city shade trees, or their protoplasm may be attacked by chemical agents such as strong acids and alkalis. Quick growing plants appear to fall in drought, as with cucumbers when started during a period of excessive rains. Plants, and especially trees, may be locally injured by winter freezing, by hail, by overbearing with exhaustion of water supply, and by a variety of causes.

While we must keep our minds open to these varying causes of impaired vigor, by far the larger number of the diseases described in this bulletin are directly attributable to parasitic fungi which attack the plant or host in some vital part and rob it of its substance. The conditions of injury arising from the attacks of insects alone are not included. These fungus parasites of particular plants are of differing sorts, which produce, each, its more or less particular effects. It must follow, therefore, that the diseases produced differ in nature and that the names applied will vary accordingly. The names are not simply blight, rust, etc., indiscriminately applied—they are given with reference both to the parasite and its effect on the host plant.

Parasitic fungi and bacteria which cause disease, being plants, though of lower class, have differences among themselves which may be clearly designated and defined. The names applied to them are accompanied by specific and generic descriptions which mark off the sort as definitely as do the descriptions on higher plants such as ferns, flowering plants and trees. The extreme minuteness of the parts of parasitic fungi and bacteria make necessary the use of the microscope in their description and detection. The parts called spores which reproduce these minute plants have special form, size, etc., by which these are recognized when found.

The agencies for the spread of parasitic diseases are those operations in which we engage or those which surround and envelop the plants as well as ourselves. Light spores will be carried by currents of air like particles of dust. All spores or germs of these lower plants may be carried by numerous agencies such as insects, higher animals, and man. They will also find entrance into plants by whatever openings exist at the time. The epidermis of a green leaf or stem has breathing pores or stomates in it; the leaves of mustard plants have water pores in them and wounded plants have those fresh openings to invite the entrance of the disease conveying spores or germs.

The remedies for plant diseases are based upon the character and life history of the particular parasitic growth with which we have to deal and upon the nature of the host plant itself—some hosts being very different from others in respect to permitting of sprays of fungicides or insecticides. Common sense inferences are always of use in dealing with plant diseases. If the soil is too wet, drain it; if late growth predisposes to winter injury, avoid such growth; if overbearing weakens plants, prevent it by thinning the fruit.

The philosophy of seed treatments is stated under diseases which infest the seed; that of soil treatments or disinfection, under soil infesting disease, and the general doctrines of sprays, fungicides, etc., under that heading further on. The progress made in plant disease prevention throughout the world during the period of about 26 years which has elapsed since the discovery of Bordeaux mixture in France shows how well adapted that discovery was to the needs of the times.

The progress made in recent years in the study and control of plant diseases has been made possible by the agencies recently developed in the United States and Canada in the Agricultural Colleges, the Agricultural Experiment Stations, and the Departments of Agriculture. It is not expected that this advance in our knowledge of the disease of plants or of the methods of disease control will soon wane. Efforts like the present one to present briefly the doctrines of disease and the philosophy of disease control together with brief descriptions of prevailing diseases in our state, have for their purpose the wider dissemination of the body of present day knowledge in these lines. Such a statement will not close the march of progress nor make less the need for more knowledge. It is hoped that cultivators of plants, whether farmers, gardeners, horticulturists or florists, will find suggestive statements of information in the bulletin by which they can direct their own efforts to better advantage and correct or broaden their own inferences from observed conditions about them. All such results will not only increase the need for more knowledge, but will furnish impetus to the movements by which we will gain the desired information.

It is fully apprehended that the host plant is the center of practical as well as economic interest and these statements concerning enzymatic diseases as in the case of peach yellows and mosaic disease of tobacco, diseases transmitted in the seed, soil infesting diseases, and the relation of the spread of certain diseases to leaf biting insects are given as aids in mastering the principles involved. The same aim has governed the discussions upon wounds and wound fungi so especially dangerous with orchard, shade and forest trees. Somewhat fuller discussion of atmospheric agencies as affecting the occurrence and spread of plant diseases, of remedies for diseased conditions and of the application of the latter in combatting diseases and a presentation of storage troubles has also seemed desirable. Special attention is called to the host plant in the matter of breeding or selection for disease resistance and in the contrasts offered by American and European points of view in plant disease study.

CONCERNING PLANT DISEASES IN GENERAL.

As defined in the introduction, a plant is called diseased when it fails to show normal vigor and normal condition of its parts. The manner of disease attack is extremely varied and the conditions set up as a result of disease are accordingly of many different kinds. We learn to recognize disease by the symptoms shown in the plant; these symptoms will at times be readily interpreted and on other occasions they will prove misleading. Nothing is plainer than the necessity for continuous observation of growing plants if one is to be in a position to interpret the symptoms of disease.

Diseased conditions may be due to the very obvious attacks of certain parasitic seed plants which lack leaf-green or chlorophyll in their tissues and must subsist on other plants somewhat after the manner of parasitic fungi. The dodders which attack the clovers, alfalfa, onions, etc., belong in the class of parasitic seed plants of the genus *Cuscuta*. Their seeds are liable to be harvested with the seeds of clover or alfalfa and to be present in the commercial seeds. While these have been treated in the weed manual they require mention here. The seeding plant of dodder first forms a root and sends upward a whitish stem which twines about the clover or other stem, and sends sucking branches into the stem interior. These haustoria extract food material from the clover stem—that is, they rob it of its own substance. Upon the formation of such organs the root of the dodder dies off and the future existence of these twining, strawlike stems is at the expense of the host plant.

A similar state of parasitic existence is found in the broomrape tribe whose very small seeds are scattered through the soil. Such a broomrape is well known on hemp, and the same hemp broomrape also attacks tobacco in Kentucky and possibly in our state. We have found another broomrape attacking tobacco in one district of Brown county, Ohio, and the illustration shows its appearance on the tobacco roots.

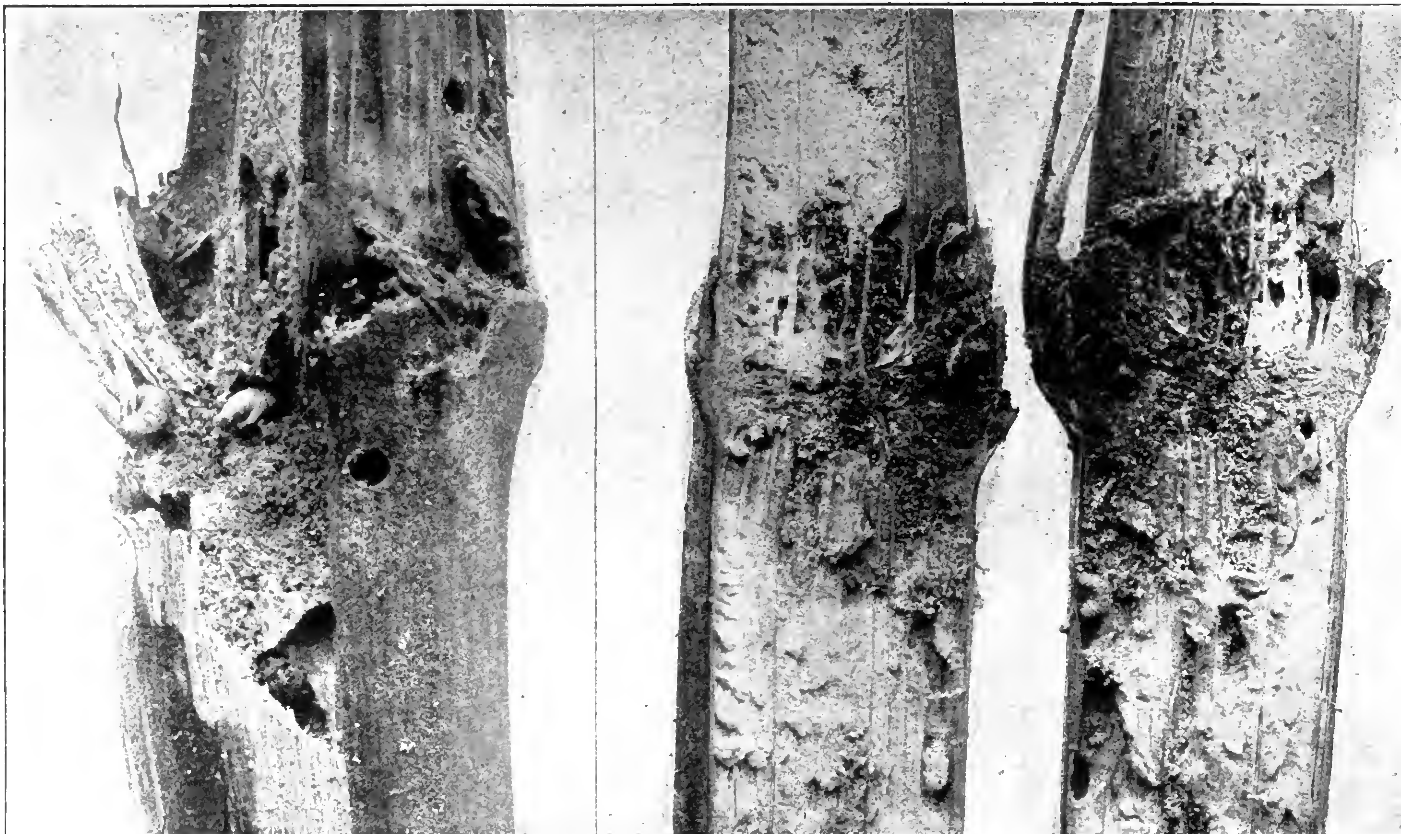
When the leaves of a plant are attacked these show the direct effects; the symptoms of parasitic leaf diseases are usually localized injury resulting in spotting and often in browning of the leaf parts. Leaves may dry up somewhat slowly and drop to the earth, and yet the leaf tissues are simply dried up. Such conditions may result from late frost as upon shade, fruit, or ornamental trees. A most interesting case was once studied upon catalpa as a result of a frost in May. In that case the drying up was none the less to be expected at that time.

An even more interesting case of leaf drying and dropping was upon young catalpa trees in a nursery caused by the attacks of a root-rot fungus, *Thielavia*. Owing to the death of many of the rootlets and finer roots as a result of the root-rot trouble, the leaves of these young trees dried up prematurely in August and September and the leaves all dropped off. Thus we may have leaf dropping as a result of frost, injury by hail, root impairment or localized parasitic attack.

LEAF SPOT AND SHOT-HOLE EFFECTS.

Leaf-spot symptoms are everywhere abundant and are really of very diverse origin. In any example in which the leaf tissues are locally invaded by a parasitic fungus we may expect evident effects. In the downy mildew troubles there may be wet-rot symptoms when the weather is moist, as in the case of *Phytophthora* or late blight attacking potato or tomato leaves; after the leaves have become badly diseased they may appear to die very suddenly because the gradual invasion of the areas has been overlooked. In many other leaf diseases no such rapid multiplication or reproduction of the parasite is possible and limited dead patches or spots are the result. The leaf-spot disease of alfalfa, the various leaf-spots of apple and the conspicuous leaf-spot of the strawberry, the beet, the pea, etc., will be recalled. In these while the leaves are impaired as to usefulness they do not perish immediately and one may readily fail to estimate the injury at its real seriousness. In a few leaf troubles we have the spotting of the leaf followed by the formation of a separation layer in the leaf tissues between the parasitized and the healthy tissues. This results in shot holes in the leaves, as is so very conspicuous in the shot-hole leaf disease of the plum and less conspicuously so on certain sour cherry trees. These leaf troubles are commonly very evident during rainy seasons and are preventable by spraying the foliage of the diseased plants at repeated intervals, thus keeping a supply of the fungicide on the leaves to arrest renewed spore development.

An interesting leaf-spot disease of the tomato is sometimes very damaging. This disease seems to have appeared in Ohio during the



Work of Coffee Bean Weevil in Cornstalks. Dept. of Agr.

memory of many close observers. Like most leaf-spot troubles which are strictly due to parasitic fungi, this tomato disease has been worst in seasons of abundant rainfall. The same applies to the shot-hole disease of the plum and the allied leaf-spot of cherry. The explanation appears to lie in more favorable conditions for spore germination and for the growth or spread of the parasitic organisms which produce the diseased conditions. Biting or sucking insects also open the way for the entrance of parasitic diseases.

LEAF IMPAIRMENT THROUGH FUNGUS COVERINGS.

In addition to the leaf-spots or dead areas in leaves to which reference has just been made, we have most noticeable examples of the spread of the mycelium of certain powdery mildews over the leaf surfaces. Casual observers note that these spread over the leaves and stems of roses, over the leaves of lilac, of oak, of peach, of grape, of forcinghouse cucumbers, of bean and pea and upon other plants. While the development of these fungi or powdery mildews occurs often rather late in the season, they are nevertheless damaging to the host plant over which they spread. Above and beyond the interference with the leaf action the impairment of the photosynthetic or sunlight processes of the leaves of the plants by which all real increase in substance is made to the plants, these mildews develop sucking or penetrating organs of the threads of the mycelium. These organs called haustoria penetrate the leaf epidermis and must do this for the purpose of food extraction—it is needless to add that all food extraction from the plant acts as robbery.

Furthermore, the mildew-covered leaves drop to the ground in fall and there afford the fungus the needed conditions for the development of the resting or winter stages of its course by which it is again ready to attack the plants the following season. Because so largely external in development these powdery mildews are usually comparatively easy of control.

WILT DISEASES—SEEDLING COLLAPSE.

The stems or branches of plants may suffer from localized attack by parasitic fungi as well as from hail, insect attack and mechanical agencies. The symptoms which follow will be found characteristic. In certain ones as in the clover anthracnose and in the fusarium of clover stems, we have the lesions accompanied by discolorations in which the fungus occupies a subordinate place outwardly. On the other hand the spots or *sori* of the rusts upon grains and grasses and the spots caused by the anthracnose of wheat, oats, rye, etc., show commonly a crowded occupation of the area by the parasitic fungus.

There are many examples of the effects of such lesions. Fuller discussions will be found under the description of the particular diseases. The anthracnose of the bean as well as that of the pea are good illustrations where these attack seedlings. Even clearer symptoms come out in potato rosette where the fungus parasite at early stages of growth may kill off the stem attacked, while in later attack will cause such impaired development of the plant that stem or axial lengthening is arrested and a rosette appearance results. A still more striking arrest of stem elongation takes place in lettuce rosette wherein the roots are destroyed so largely by the fungus in the soil. (See Soil Infesting Diseases.)

In cankers of branches upon orchard trees the final death of the immediate branch is preceded by a depressed area invaded by the parasite.

PLANT DISEASES NOT BEYOND EXPLANATION.

The old mystery attached to disease prevalence can scarcely be maintained in our day. We have worked out in recent years or had determined for us the causal relations between the ferment or parasite and the effects upon the host plant or crop. So far as we can now discover the reason for the spread of diseases, or of a particular disease, is found in the specific disarrangements in the host plants. This discovery and announcement of these causal relations are undertaken that proper measures for the control of diseases may be finally devised and applied. We must always bear in mind that under favorable conditions plant diseases become epidemic and their rapid spread is to be expected.

The host plant, with its climatic adaptations and the parasites of our crops with their mutual adaptations to their hosts are biological factors which are capable of being influenced by prevailing atmospheric conditions. With cool, rainy weather we have brought about conditions favorable to certain parasitic diseases which will be inclined to spread while these continue. Other diseases spread under the conditions which favor them. The more rapid development of diseases of plants under these favoring circumstances is not beyond reasonable understanding; there is no mystery about it any more than in outbreaks of typhoid fever or diphtheria. By apprehending the differing conditions we may learn to separate the causal from the merely adventitious factors and thus be the better able to master the diseases which result.

While we may properly look upon infection by microscopic or other parasites as the general and usual cause of plant diseases, there are diseases of wide importance which arise from internal or physiological disarrangements in the plant. (See Enzymatic Diseases.) In all cases whether of parasitic attack or of physiological disarrangement due to other causes, the host plant is weakened and predisposed to death.

GROUPS OF PARASITIC DISEASES.

Parasitic diseases may be grouped in a way, according to the groups of fungi which cause them. This is helpful to the plant pathologist, though of limited practical guidance, since it requires microscopic study to determine the causal organisms. A more useful, limited grouping as is hoped is proposed below and consists in making such groups or classes of diseases as are descriptive of the general behavior. Such are seed infesting diseases, soil infesting diseases, root diseases, diseases of foliage, wound troubles, timber rots, etc. The great mass of diseases are treated under each host in the descriptive portion arranged alphabetically. The objects to be attained by this method of arrangement are obvious and call for no discussion.

NAMING PLANT DISEASES.

Plant diseases are named with due regard to the symptoms and causes of the disease. In the case of enzymatic diseases wherein we have peculiar variations or yellowing of the leaves, the names given are more or less descriptive. The same applies to the diseases that are caused by freezing, hail, etc.

Parasitic diseases are named with regard to the organisms which cause the disease, or to the effects they produce in the host parts, that is, those diseases which result from attacks of the rust fungi (*Uredineae*), are properly called rusts; also the smutty, dirty conditions resulting from the attacks of the smut fungi (*Ustilagineae*), are known everywhere as smuts; these are well known and destructive upon grasses and cereals. Thus we have smuts of oats, corn, wheat, broom corn, sorghum, millet, blue-grass, etc.

The anthracnoses are produced by a definite class of fungi (*Melanconiae*). The name anthracnose is applied to a disease of a given host caused by an organism of this group and the host name is usually retained, as the anthracnose of wheat, the anthracnose of rye, the anthracnose of raspberry, wherein the diseases are caused by species of this group of parasitic fungi. However, in the case of attack upon the fruit as in the anthracnose of apple, because of the bitter taste given to the fruit, we have the popular name bitter-rot; in a similar instance, viz., that of the anthracnose of the grapeberry, the discolorations of fruit are so characteristic that it is popularly called the birds-eye rot. With wheat, oats, rye, etc., the name is applied because of the organisms found. As stated in the preceding pages, we describe most leaf infesting diseases with regard to the effects the parasites have upon the host; thus we have the leaf-spot disease resulting from attacks of any one of a number of fungi, chiefly, however, belonging to the imperfect forms. The shot-hole fungus of the plum is a good illustration of the naming of a trouble from the symptoms produced.

A considerable group of diseases are known as downy mildews. Among these we have the destructive potato late blight and rot, *Phytophthora;* also the cucumber disease, *Plasmopara,* as well as the grape downy mildew and the common white molds of the mustard family. The powdery mildews by reason of the appearance upon the surface of parts attacked, are descriptively named mildews. A definite system has been followed in most cases of naming plant diseases and I trust the results will not be altogether disappointing.

The differences between the species of parasitic or other fungi are as strongly marked as those of higher plants, even though microscopic examination is necessary to distinguish these characters; it shows, therefore, that a discriminative system of naming diseases has a secure foundation.

THE PLANT OR HOST IN RELATION TO DISEASE.

As stated elsewhere only closely related plants are usually subject to attack by a parasitic organism, thus it happens that the tomato as well as the potato plants are attacked by the downy mildew or late blight fungus of the potato. In general the true parasites among our fungi are limited to a rather narrow range of host plants; thus we may expect the potato *Phytophthora* to attack several plants of the potato family (*Solanaceae*). The investigator proved this same was true of the attacks of downy mildew (*Plasmopara*) upon a number of species belonging to the cucumber family (*Curcurbitaceae*). Since our cereal grains belong to the same great family as the grasses (*Gramineae*), we expect, and find that there is a development of the same diseases upon many of them and upon the grasses growing near by. In this connection it must be remembered that clover and alfalfa are not grasses, but legumes.

The leaves of the host plant provided as they are with stomates or breathing pores, minute openings through the epidermal covering of the leaf, will be attacked through these openings. The spores of parasitic fungi after germinating upon the leaf will likely gain entrance into the interior leaf tissues through these openings much more readily than by actual boring through the leaf epidermis.

These stomates are present in the leaf covering upon the outside of all green leaves and in the epidermis of young growing shoots. In addition to these stomates certain classes of plants such as the plants of the mustard family (*Cruciferae*), as cabbage, cauliflower, turnip, also the grape, fuchsia, impatiens, etc., are provided with water pores—marginal openings through which the excess water of the plants is excreted. These water solutions of various materials offer a means of growth for organisms, especially of the minuter forms. From the culture drops thus formed the parasite enters the leaf by the water pores. One of the most destructive known diseases of plants is the black-rot of cabbage, cauliflower, turnip, ruta-baga, etc. This is due to a bacterium which gains entrance very largely through the water pores just described. So we must bear in mind that the very avenues of transpiration or excretion, so essential to plant growth, are made a means of exposing the plant to the danger of parasitic invasion. This is analogous to the exposure of human subject to diseases of the respiratory organs. At every turn we find convincing evidences of the mutual adaptation of parasitic fungi to their host plants, in nothing more strongly marked than in the limitation of the species of plants attacked by a given parasite as discussed in the beginning of this paragraph. In view of the fact that so long as the leaves of a plant continue to function as leaves, these natural openings will be maintained, it will be seen that the risk of exterior infection from parasitic fungi is continuous for any given plant; it lasts for its whole growing period.

THE PLANT'S PROTECTION AGAINST PARASITES.

In the case of woody growths we have the development of corky epidermis or bark which seems primarily designed to protect the interior, living layer from invasions of this sort. In a similar manner the external layer or bark of all growing plants, including herbs, is provided with a protective covering or epidermis. The skin of the apple or of the grape and the covering of the potato stem are all familiar and serve this function of protection to the inner tissues. In young plants there is retained the power of protective growth in response to resistance to parasitic attack; thus it happens that the potato scab organism induces the growth of cork cells on the outside of the potato and makes a roughness. The roughness is not the scab fungus but the corky growth of the tubers in response to the scab attack. In a similar manner the attack of the scab fungus upon the apple results in the roughening of the apple skin through the development of more protective or wound cork. The most remarkable example of this multiplication of protecting or outer cells in response to the attacks of parasitic fungi is found in leaf-curl of the peach and in the pockets or bladders of the plum, where we have such a rapid multiplication of cells in response to the stimulus of the fungus as to bring about an entire transformation in the form and structure of the parts. While we may think of this abnormal development as the result of fungous growth, it is only indirectly so. It is in fact a response of the host to the stimulus of the invading fungus. The nature of the stimulus or excitation exerted by particular parasitic fungi is a highly interesting subject for investigation.

CONCERNING PARASITIC FUNGI.

A fungus (plural, fungi) is a plant, a member of the class called fungi. The fungi are low in the scale of plant life, being classed with the algæ and other similar plant forms. They are lower still in the life scale than the mosses and liverworts; above the mosses come the fern-plants, and above these the seed plants, such as grasses grains, clovers, trees, shrubs, herbs and the like, with which we come in contact every day. The fungi are distinguished from higher plants as well as from their nearer relatives, the algæ, by the absence of green color, and for that reason, we may assume, by the lack of power to prepare their own food from the mineral substances dissolved in water, and from the gases contained in the atmosphere. Herein they are marked off from most groups of plants: the fungi must live upon the substance of living or dead plants or animals. If they ever possessed the power of utilizing the same foods as most other plants, this ability has been lost. Parasitism is usually taken to indicate degeneracy in character. One way of regarding the fungi is as algæ without chlorophyll, to which the latter owe their green color. As above stated, the fungi are, in the absence of chlorophyll, forced to live upon the dead remains of plants or animals, or to prey upon the living organisms.

CLASSES OF FUNGI.

Such fungi as subsist upon living plants or animals are called parasitic fungi. A parasite is one who eats at another's table and the adjective parasitic comes from this word, parasite. It is the parasitic fungi especially of which we must learn, since this class produce diseases when they attack other plants. The plant attacked is the host plant, however unwilling the entertainment of the sycophant.

Most fungi are very minute in size and require the use of a microscope to study their parts; certain ones, however, such as the mold upon bread or other foods, may be seen very easily to consist of fine, thread-like growths interwoven together, and bearing certain rounded parts upon erect branches. Some idea of fungus-structure may be obtained by studying these common molds; that on a discarded melon rind will show the parts above described, and by the use of a microscope we may learn that the rounded, ball-like enlargements just mentioned consist chiefly of small bodies that are capable of growing into other fungus-threads. Such minute parts capable of germinating and again producing the fungus are called spores. Most spores are very minute and are not heavier than the other dust particles carried by the wind. The spores of fungi are the means by which these are most commonly reproduced, somewhat after the manner that the higher plants about us are reproduced by their seeds.

While we have cited the bread mold as a good illustration to show the structure of a fungus, it is not a parasitic fungus; a mold or like growth which lives upon decaying material is called a saprophytic fungus. To this same belong the mushrooms or toadstools that may be found in manure piles, in the woods and in orchards; the fact that we find them in such places shows that there is decaying organic substance at that point, upon which these plants may subsist. A like condition is found in the shelf-fungi on old logs and stumps, on the under surface of which we may write our names. Yet if we will use a hand lens we may often discover this under surface to be but a network filled with small openings or pores from which the spores of the fungus will in time escape. In like measure the spores of mushrooms are found in similar canals or upon the sides of the gills beneath the cap of this sort of fungus. The bacteria, or fission fungi, are one-celled plants multiplying by division and by spore production; with bacteria evident mycelium is lacking and they are structurally lower in the scale of plant life than fungi provided with a mycelium. Bacteria are both parasitic and saprophytic. But to return to parasitic fungi:

PARTICULAR FACTS ABOUT PARASITIC FUNGI.

Like the bread mold, or the other fungi just mentioned, parasitic fungi consist of a growth of threads or hyphae (singular, hypha) which do the necessary work of getting food for the parasite; these also in due time give out certain branches destined to bear spores, somewhat after the manner that the pear tree has flower clusters, or the wheat plant forms its dense spike of bloom, both of which are especially designed to produce seeds from which wheat plant and pear tree may in turn be grown. The essential parts of a parasitic fungus are these threads, or hyphae, and the spores produced by them. The hyphae of the fungus taken collectively are called the mycelium, which consists of threads that produce no spores (sterile hyphae) and of those destined for spore production (fertile hyphae). It is to the food getting qualities of the hyphae that the fungus owes its continual existence, and they in turn arise from a spore or directly by the growth of some fragment of fungus-thread, as the Carolina poplar may be grown from a cutting. Yet, while all parasitic fungi are made up of these few parts, the differences in form and apparent structure among the several groups are very marked; differences exist as to the thickness of the hyphae whether or not the threads are divided into separate cells by divisions like those at the joints of a bamboo rod, as well as in the manner of spore formation and in the size, color, form markings and structure of the spores themselves. It is almost hopeless to undertake to illustrate types of spore production and spore forms, since these are so varied and may differ so much at different stages of the development of a single given species of fungus, yet we may cite a few examples:

Fungus spores may be produced as single spores or in naked clusters attached to certain branches. We find this sort in the downy mildew of the cucumber and its relative the peronospora of mustards; in potato early blight; in fruit rot of plum, cherry, peach, etc., and later in the spores of apple scab. They may also be found in dense clusters breaking through the skin of the plant like the many tubers of a potato breaking through the earth-crust; such without further conspicuous covering are found in the rust spots, in the anthracnoses and the like. These dense clusters may arise beneath a special covering resembling nothing so much as the traditional beehive, but are usually ejected forcibly from a specially provided opening at the top of the cone or half-ball. A yet more interesting class is that in which the spores are packed so many to a sac (usually eight) and a large number of these crowded into a ball-like, hollow spore-case, such as we find in black-knot, strawberry leaf-spot, the powdery mildews and in some other instances. There is yet another sort in which the spore sacs are abundant near the surface of the diseased part, as in leaf-curl of the peach, where the maturity of the fungus is shown by the change in color of the affected leaf surfaces. Other gradations will be found as one proceeds in this study.

THE SURVIVAL OF PARASITIC FUNGI.

Further, respecting parasitic fungi we must realize that they are all derived by specific processes of reproduction peculiar to the fungus in question; in other words spontaneous generation does not find support among the students of plant diseases.

The presence of any given fungus leads us at once to infer the previous existence, somewhere within reach, of a fungus of like species from which this one was derived by definite methods of reproduction. Likewise, the destructive prevalence of a parasitic fungus in any given time and at any given place, assures us of the necessary supply of spores to start the trouble again under favorable conditions. In fact, all our study leads us to look through mere phenomena, mere evidences of disease, to find the specific parasitic growth which causes them and the favoring conditions under which these develop. The spores of fungi serve for them the same purpose as do the seeds in higher plants; by reason of the extreme smallness of the spores they are easily transported by the wind and become deposited like dust particles upon exposed surfaces. Certain resting spores survive on the fallen leaves or other parts and will be destroyed if these parts are burned. (See Black-knot.) The survival of organisms capable of infecting the new crop is certainly to be expected in plant diseases as in epidemic disorders among people.

Some fungi which produce disease survive by their thread-like parts (*mycelium*) in a manner similar to the survival of Canada thistle, quack-grass and the mints among troublesome weeds by their visible underground stems. A good illustration of this form of survival is found in the case of potato rosette; in this disease the masses of mycelium (*sclerotia*) remain upon the surface of the potato tubers and unless destroyed by treatment of the seed will be ready for immediate attack upon the growing plants (sprouts), even before these have reached the outer air and taken on a green color.

Similar survival may occur in cultivated soils, especially where the same or closely allied crops are grown in succession. Thus the same fungus as that of the potato disease first named, survives in greenhouse soils or in celery soils outdoors.

RESTING FORMS AMONG FUNGI.

The active parasitic phases of fungi necessarily coincide with the activity of the host plants; it, therefore, follows in our temperate climates with alternating periods of activity and rest of growth and practical somnolence, that the parasites require to be mutually adapted to intermittent activity. Some spores will survive the brief rest period between harvest and seed time, as in a number of the various grain smuts and in grain anthracnoses. Here they are found simply adherent to the seed grain.

Seed infesting parasites like the loose smut of wheat, the anthracnose of pea and bean, and a variety of other vigorous species survive as resting mycelium, which remains virtually inactive so long as the parasitized seed is not exposed to conditions of moisture and temperature such as bring about germination.

There are endless gradations between these instances of resting mycelium and the protected fruit cases of the higher type of fungi. Thus the perithecia or closed fruit bodies of the wheat scab fungus, develop shortly after harvest upon the infected glumes or culms of wheat, and may be observed by the unaided eye, as black bodies seated upon the pink mass of the summer form. These fruit bodies in this case are the kind called perithecia, which contain within them spore-sacs of a nearly fixed number and each sac contains a fixed number of spores of definite form for each species. A great many fungi develop these housed or protected forms during the dormant period, and indeed, spore development may proceed in the periods of lower temperature.

With the perithecial or sporehouse form of wheat scab (*Gibberella*), the spore sacs are formed during the later summer, in our latitude, and these spore sacs disappear before midwinter. For each genus or species under study, peculiar time relations of development may be discovered. The perithecial or spore sac (*acsigerous*) form just described, or some comparable development of the spores under a definite cover-form, is viewed as a more or less ultimate stage in the development of the higher fungi—the summit in the cycle of their development.

The rot of stone fruits, such as peach, plum, cherry and the like, is commonly known only in its conidial development called

Botrytis. Recently Norton has discovered the *Sclerotinia* or ascigerous stage developed from the mummy fruits in which the fungus lay dormant for a time awaiting spring or summer conditions.

The bitter-rot of apple and its cycle of development not long since brought to light in Illinois, also shows the relation of the apple mummies, decayed by attacks of this anthracnose, to its survival. The fungus lives over in the old rotted fruits, acted upon by bitter-rot alone, which hang upon the trees. The fungus may also survive in branch cankers upon the tree adjacent to mummies of the bitter-rot. In these branch cankers the spore sac or perithecial stage of the fungus is developed. Upon the coming of warm showery weather about early June, new spores are produced from either mummies or cankers and new infection may occur upon the new fruits. The problem of the control of this disease, therefore involves a knowledge of its manner of survival.

ALTERNATION OF HOSTS IN FUNGUS SURVIVAL.

This relation of alternating forms in the life cycle of a given parasitic species, to its survival, has been mentioned in wheat scab wherein we have the *Fusarium* or pink mold and the *Gibberella* forms; in rot of stone fruit where we find *Botrytis* and *Sclerotinia* forms, and in apple anthracnose or bitter-rot where we discover the *Gloeosporium* followed by the *Glomorella* ascospores. In these instances there seems no real need for the advent of another host plant. In other groups of fungi, notably among the *Uredineæ* or rusts, we discover in certain species, that survival is accompanied by a necessary change of host plant. The apple rust is known in summer to attack the leaves and fruit of apple, thorn apple (*Crataegus*), juneberry and mountain ash. This is the aecidial or cluster-cup stage of the apple rust and has its counterpart in the aecidiospores or cluster-cups of the wheat rust upon barberry as well. With apple rust we climb far on the plant ladder and find the teleutospores of rust survive upon the cedar trees as branch enlargements called cedar apples (*Gymnosporangium*). The dry looking apples upon the cedar trees take on a new form during spring showers when they become great, jelly-like masses which emit the teleutospores of the rust, to be carried to apple, juneberry and crataegus leaves by whatever agency is available.

The relation of cedar trees to the prevalence of apple rust is a practical matter for each orchardist. It may be better to make firewood of the cedar trees than to combat the apple rust in his orchards. A similar problem as between the barberry hedges which adorn rural England, and the virulence of wheat rust in their grain fields, may also be raised. With us we have plenty of grain rust in the absence of barberry hedges. An adaptive form of survival apparently takes the place of the alternating hosts, and we still have the wheat rust.

The instances given are simply illustrative and the student of plant pathology will discover many more in the course of his study. Likewise a careful perusal of the special part of this bulletin will show other instances of survival under many various and instructive conditions.

HOW THESE PARASITES ROB THE HOSTS.

There is an old saying about the stable door and the stolen horse; similar application may be made for plants and parasitic fungi in a manner which we shall presently perceive. To obtain food we must reach the source of supply; the manner of reaching it is less important than the result. Now it occurs that cultivated and wild plants of the higher classes are wrapped about by a covering of skin or bark, and the food-filled juices are within; to feed upon any living host the parasite must gain access to the internal tissues of that host. It so happens that there are minute openings or stomates (breathing pores) through the skin of leaves and of young green stems; these openings are as necessary as the stable door, and through them the thief may enter. Were these openings to become entirely closed the plant would languish, and remaining open, they constantly offer a way for the tender tip of the growing germ thread of a fungus to push its way through the plant covering and to luxuriate within the host upon the substance of the plant. Once within, the fungus thrives, rapidly multiplies its branches, and if in summer, commonly thrusts its fertile threads through some of these breathing pores to bear its spores outside where they may become more widely distributed than if remaining within the tissues of the host plant. Should, however, the winter season be near, resting spores may be formed, or their formation be provided for within the leaves, or diseased parts, as in grape downy mildew, elm-leaf disease and in black-knot of plum and cherry. Thus the cycle of development continues indefinitely unless some agency intervene to destroy the spores, to prevent their germination, or the parasite itself so exhaust the host plant as to destroy it entirely and the fungus perish for lack of suitable nidus. However, this rarely occurs, not perhaps, so often as men are guilty of killing the goose which lays the golden egg. Herein, we meet another fact, namely, that parasitic fungi of a given kind are limited to a particular host plant of a certain species, or to a small number of related plants, so that if a congenial host is lacking the fungus will not thrive.

The fungus thread growing within any plant will not flourish if simply passing between the cells of the host; penetrating organs pierce the cell walls and are able to absorb nutriment from the cell interior. The diverse forms of sucking organs, and the peculiar structures of fungus threads in these situations would in themselves require much study and investigation to present them properly. We must further conceive that a fungus may often penetrate the bark of a tree for example if aided by rifts caused by freezing or similar disturbances, to say nothing of the openings offered by wounds, the breaking of branches, etc. A recent illustration of the danger of rifts in the bark of trees is offered by the chestnut disease which is proving so destructive near New York City. Few parasitic fungi have that penetrating power of thrusting the haustoria through the plant covering such as we find in the case of the dodder that twines about and robs the wild herbs and shrubs of the woods and fields as well as the cultivated flax and clovers.

HOW PARASITIC FUNGI AFFECT THE HOST.

We know the cumulative effects of insufficient food supply; these effects must hold for plants attacked by parasitic fungi. Aside from the nutriment diverted to the parasite, there is reduced functional vigor of leaf, stem or root, and the loss becomes increased in this way. Let all the leaves be parasitized, or let even three-fourths of them be entirely so attacked, and we may look for great loss of foliage, possibly entire loss of fruit and the detailed effects of diminished vigor, unripened wood, or by repetition, entire destruction of the host. Usually the effects are of many gradations, but in all cases of leaf parasites the entire plant must suffer. We have learned that bacteria may, in a suitable medium, destroy themselves by the formation or emission of poisonous products which are fatal alike to the bacteria and to animals, or even man; that such takes place within plants parasitized by fungi remains in doubt, and may be disregarded for the present. The results of impaired function in the parts are serious enough to demand our attention. It is altogether probable that future investigations will modify our views upon some points.

There are many curious transformations and malformations resulting from the attacks of parasitic fungi, simply by the multiplication of cells of wound cork or other tissues in the effort of the host to shut off the fungus, not because the fungus consists of such a mass of tissues. (See leaf-curl of peach.)

While exceedingly interesting to trace the effects of the white mold on shepherds purse and on the garden purslane, as well as the effects of bramble rust, cabbage club-root and a number of others, the principle above pointed out will be found generally applicable, and it is to the reactions of the host plant that the excrescences or malformations are chiefly attributable. It may further be stated that artificial cultures of parasitic fungi, either upon culture media or living plants are constantly adding to our knowledge in these lines.

BENEFICIAL ORGANISMS: ROOT NODULES, ETC.

While realizing the losses caused by parasitic fungi and bacteria we may not hastily condemn all fungi and bacteria. One of the most profound influences of aging culture of the soil is the beneficial effects in nitrogen fixing, exerted by the root nodule bacteria of leguminous plants. The well known beneficial effects of the root nodule bacterium upon clover has made rotation in clover an agricultural necessity. The species or forms of root nodule bacteria required on alfalfa, cowpeas, vetches, etc., have become recognized as factors of consequence in our efforts at seeding and new species of legumes on the farm.

A less understood relation between certain fungi which develop as mycorrhiza upon the roots of some deciduous trees and notably on conifers may not be passed. Herein we may find an explanation of rotation in forest species when reforestation crops are to be grown.

THE PROOF OF PARASITIC CAUSE IN PLANT DISEASE.

The mere presence of a fungus, determined by the microscope in diseased tissues of the plant, does not prove the case against the organism found. It is not easy at all times to be certain whether discovered spores belong to this or that organism, or group of organisms, although with certain groups as the anthracnoses, species of Fusarium, etc., the spore forms give somewhat clear evidence. The differences between parasitic and saprophytic fungi are not always simple matters admitting of ready determination; further, we must bear in mind that after a parasite has caused death, or even minor lesions in a plant, the organisms of decay may be expected to appear to do their great work as the scavengers of the world. The fungi or bacteria found in a dying plant may be both saprophytic and parasitic, or these may be only saprophytic.

The methods of proof of parasitic cause in the bacterial diseases of animals including man have been extended to the study of bacterial diseases of plants and finally to the diseases caused by parasitic fungi. These methods consist of a group of rigorous exact rules which are stated by Dr. E. F. Smith in the following terms:

(a) Constant association of the organism with the disease.

(b) Isolation of the organism from the diseased tissues and careful study of the same in pure cultures on various media.

(c) Production of the characteristic signs and lesions of the disease by inoculations from pure cultures into healthy plants.

(d) Discovery of the organism in the inoculated, diseased plants, re-isolation of the same, and growth on various media until it is determined beyond doubt that the bacteria in question are identical with the organism which was inoculated.

While these methods and rules are stated with special reference to bacteria as the cause of disease, they apply with equal force to the proof of cause in the case of any given parasitic fungus. These methods require rigorous and exact work in the isolation and subsequent culture of the parasite upon sterile media, followed by equally careful inoculation work using these pure cultures as a source of the organism.

CULTURE PROOF NOT ALWAYS POSSIBLE.

While in all cases of bacterial diseases where the body of the organism is so little different from that of the bacteria of decay, fermentation, etc., these rigorous proofs are required before the disease is listed as of proven bacterial origin, we do not find it necessary in practice to reprove again the case as against frequently occurring species of fungi associated with particular plant diseases. This does not make it less necessary to prove all cases as to parasitic cause, although the practicability in any single laboratory of pathology is admittedly one of narrow limits.

ENZYMATIC DISEASES OF PLANTS; CHLOROSIS OR PANACHURE.

To this form of physiological breakdown, induced however, by specific causes recently determined, we attribute some very widespread and injurious diseases which belong under the head of chlorosis. Peach yellows, possibly peach rosette, frenching or mosaic disease in tobacco, and in general variegated or special yellow foliage types of plants as in Arundo, Acer and other genera of plants belong here. The yellows in peach has long been studied, as also the tobacco mosaic disease. In yellows the contagious character of the disease and its transmission in pruning by contact of parts of the harness of team and by or through the atmosphere has been recorded.

A few years ago it was determined by Beierjink and by Hunger that this infection exists as a chemical compound or compounds of complex nature belonging to the oxidizing ferments of a group called the oxidases. Oxidase, peroxidase and others of these ferments are known. They act by breaking down or oxidizing the plant leaf tissues and especially the chlorophyll or leaf-green of foliage and young tissues, converting it into xanthophyll. The tests for these ferments are of some importance. Woods and others have shown their action with peroxid of hydrogen.

From a practical point of view the transmission of the ferments, and, therefore, of the disease, by touching first diseased and then healthy foliage is rather surprising, The work of Hunger in Java upon the transmission of the tobacco mosaic disease makes the risk of transmission from diseased to healthy plants by such handling, stand out clearly. This line of transmission was verified on tobacco by the writer's assistant in 1903. (See Bulletin 156, of the Ohio Station.)

While the same class of proof for peach yellows is very difficult, owing to the latent nature of the disease for some months after first infection, the actual results of infection from nearby diseased trees make clear the danger of such exposure and the necessity for the destruction of diseased trees. Chemical examination of variegated or chlorose tissues shows the same compounds, the oxidases, etc., to be present and to account for the transformation of the leaf-green or chlorophyll, into xanthophyll, or leaf yellow. Thus by degrees apparent plant disease mysteries are solved. The weakness of variegated plants and their ready susceptibility to attacks of parasitic fungi are now explained by this impaired condition of the leaf parts.

PLANT DISEASES TRANSMITTED IN THE SEED.

The public in general little realizes how many diseases of plants are transmitted in the seed, although as the years pass the general dissemination of knowledge concerning infection by spores and by germs has partly prepared the way. The public mind does not longer expect something to grow from nothing. The treatment of seed grain, as wheat, oats, barley, etc., to destroy adhering spores of the smut fungi, and thus prevent these smuts in the crop, has been known for many years. In the early days of the Agricultural Experiment Stations, these doctrines and practices in this regard were widely disseminated, new impetus being given by the successful use of hot water following the methods of Jensen in Denmark; but despite the conquest of the practice control over the order Ustilagineae, the smuts, we have only really begun to study the matter of seed infecting diseases produced by seed infesting fungi. These seed infesting fungi are of two types, viz., first, those whose spores adhere to the seed grain as in the case of the smuts of grains generally, and second, and more exactly, those fungi which develop upon or within the seed largely by their threads or mycelium, and may, or may not, prevent the germination of the infested seed grain. Our knowledge of these strictly seed infesting fungi is quite recent; we may point to the work of Prof. Bolley and his assistants at the North Dakota Experiment Station, especially upon the matter of flax diseases; to the work of Dr. Halsted in New Jersey and to Bulletin 173 of the Ohio Station by Van Hook. With the tendency to continuous growing of flax, in the west there was developed in that new area specific seed and soil troubles which have been proved to be perpetuated in the infected seed. An anthracnose of flax and a Fusarium attacking flax seed are examples.

No less conspicuous is the case of the blight fungus of peas, *Ascochyti pisi,* which is also an anthracnose, and the allied anthracnose of beans, *Colletotrichum lagenarium.* Investigations made at the Ohio Station by Van Hook show the source of the trouble with peas to be the infected seed employed and show also that seed treatment will not destroy these internal fungi without destroying the vitality of the seed. It was further shown that the source of relief lies in growing healthy seed through the use of fungicides upon the pea vines from which seed is gathered; likewise that infection may remain in the soil. More recent work at the Ohio Station has shown the presence of seed infesting and seed infecting diseases in wheat. (See Bulletin 203.) It was also found in continuous wheat land as much as 6 per cent of the young wheat plants were destroyed in the fall by this same parasite which appears to survive in the soil under continuous wheat growing as well as to be propagated in the seed grain.

PARASITIC FOLIAGE DISEASES.

Foliage diseases of every sort are caused by oxygen loving or aerobic species of parasites, and very often this development on the leaves consists of the imperfect forms of the fungus life history. These forms are none the less aggressive and injurious for this reason, but the exact manner of survival from year to year becomes important wherever not known. The application of this to preventive measures in the control of these diseases upon foliage and fruit is seen in the case of apple scab, the monilia rot of plums, peaches, cherries, etc., and in apple bitter-rot. These last two rot troubles survive in the mummy or dry rotted fruits and this explains the reason for the oft repeated injunction to destroy all mummies in addition to spraying operations. The bitter-rot of apples is propagated by means of summer branch cankers on the tree, as brought out in recent years. Other leaf forms survive on the fallen leaves or possibly in bud scales as with the leaf curl and bladders of the *Exoascae.* A large number must live over on the branches.

Parasites upon foliage soon become apparent from the spots on the leaves and dropping of fruit resulting. This dropping may come as a result of impaired vigor by reason of disease—then it is later, but is more often the direct result of parasitic attack by the disease upon the young fruits. Herein as elsewhere the philosophy of fungicides comes to our relief. A good foliage fungicide is a relatively insoluble compound which will not greatly injure the leaves with which it is in contact. The remedies for foliage troubles are applied in *anticipation of attack* and for the purpose of checking the fungus when it may appear. The relative efficiencies of various fungicides in early summer will possibly depend upon the sticking qualities of the sprays.

Foliage diseases, moreover, are liable to recur each year and this is an added reason for anticipatory treatments to ward them off. *Foliage diseases may not be neglected with impunity since the leaf is the plant's vital working organ and the plant must suffer from its impairment.*

BITING AND SUCKING INSECTS AND LEAF DISEASES.

The part played by insects which wound the leaf epidermis, in the spread of leaf diseases, is often very important. Such wounding of the leaf or green stem whether by insects such as flea beetles, foliage eating worms, or by sucking insects such as mites, leaf hoppers and plant lice, opens the way for the spores of parasitic fungi or of bacteria or mere molds, any one of which may be injurious to the leaf. The early blight disease of potatoes is a good example. In seasons when there are many of these little black flea-beetles to puncture the leaves, the thorough control of both these insects and the early blight, *Alternaria* fungus, is called for. Many fungi of doubtful penetrating powers are truly injurious when they follow insect punctures of the leaves. Fortunately both these are secured by Bordeaux sprays. The reasons for such applications are of double character since they are to combat both the insect and the fungus to follow it.

With shade trees the leaf hoppers and mites may be so numerous that tip-burn and various leaf dying results from the injuries or punctures they inflict. A more startling relation is that of the blade blight of oats, a recently investigated bacterial trouble. This bacterium is distributed and inoculated very obviously by the aphids or green flies (plant lice), and other sucking insects.

WOUNDS AND WOUND INFECTION.

With woody growths, especially in trees which attain considerable size, we have the various phenomena of disease infection through wounds; this infection later becoming evident by reason of decays set up in the woody tissues. Of course, in instances such as the bark disease of the chestnut, *Diaporthe parasitica* Murr., the disease may penetrate the living tissues. Not so, generally, in wounds of woody plants. Any large wood growth as in forest or shade trees and in larger fruit trees, shows the combination of an external or living sapwood layer and an internal dead or heart-wood cylinder. The commoner forms of wound infections are attributable to those species of fungi which cause decay of this dead heartwood. Among these are the long list of saprophytic, agarics, polypores and stereums. Because of the fact that this heartwood cylinder is dead, these saprophytic species of fungi, once they gain entrance into it, flourish there and invade the wood to a very great extent, even by adaptation to parasitic habit extending their work into the living parts causing death. The removal of a large branch of a shade tree or a fruit tree, unless the wound thus formed is properly protected by dressing, opens the way for spores of these fungi which cause timber decay to obtain a start and thus eventually to invade the heartwood of the interior. For dressing cut-off branches, asphaltum is admirable; in its lack gas tar is good, and either is better than ordinary paints.

There is always to be borne in mind that the protection of the woody cylinder of trees depends on its being covered by the living layer of sap wood. Every branch of considerable size connects directly with the extensive heart cylinder; we thus see that the wound fungi which attack the heart wood are the timber decays and their presence emphasizes the need for care in providing protection for all wounds, especially those caused by pruning.

Any decay becoming established in the dead heartwood may extend for long distances through this dead wood and in the end so destroy it as to be in a position to invade the external or sapwood layer.

In addition to the exposure of the internal woody cylinder to these decays, we have sap-rots due to various species of fungi which belong on the border line between the parasitic and saprophytic sorts: Among them are species of Fomes, Polyporus, Lenzites, etc. Any wound of the sapwood even though it does not reach to the dark heartwood, exposes to the danger of this infection, and with infection, to all the consequences of sapwood decay and premature death of the tree. These decays and those of heartwood are in line with those of the rots of structural timbers, but we are at this time interested only in their effects on the parts of the living plants.

TIMBER ROTS AND TIMBER PRESERVATION.

The decay of dead logs, wooden frameworks, or other structural timbers is caused by the attacks of saprophytic fungi belonging to the gill and pore fungi mentioned under wounds; these are of the great class of basidium bearing fungi, to which the fleshy forms, everywhere more or less abundant, belong. The most of them are included in the mushrooms, which there is a strong impulse now to study and illustrate by photographs. These timbers are dead and are subjected to invasion by timber infecting species wherever the conditions as to air and moisture are such as to favor their development. Dry timbers are not subject to such attack because lacking the requisite moisture for the organism. Floors and other timbers of houses adjacent to the earth or to unheated cellars are often attacked by rot-causing species. The timbers of trestles, railway ties and the bases of fence, telephone and telegraph posts, where inserted into the earth or in contact with it, are kept sufficiently moist to invite attacks of this sort.

Wood that has been invaded by such fungi is reduced to the state called punk: that is, the wood fibers and arrangements in vessels to which the timber owes its strength, are broken down by the invasion of the fungus which flourishes at the expense of this woody

Work of Peach Tree Bark Beetle. (Phloeotribus Li[illegible] [illegible])

(See page [illegible])

tissue. There is no help for timber after it has once been attacked by rot fungi. Whatever preventive measures are taken must precede the attack. The most effective means of timber preservation is to cause it to be injected or permeated with creosote or other antiseptics. This is done by placing the timbers in vats containing the solution and extracting the air from the timbers so far as possible. The permanence of the effects of such timber treatment depends upon the resistance offered by the material used to gradual solution by water. In the case of creosote the results are quite satisfactory; with chloride of zinc, subsequent solution takes place too readily, while with crude petroleum there is a tendency toward the evaporation of this substance when injected. The increasing cost of timber will stimulate timber treatments by making treatment profitable. One drawback at present is the necessity to import creosote for use in such work; possibly refinery by-products from petroleum of a character analogous to asphaltum may find application in timber treatment.—(Ohio Agr. Ex. Sta. Bul. 214.)

ATMOSPHERIC CONDITIONS AS AFFECTING PLANT DISEASES.

The relation between weather and the prevalence of certain plant diseases has been often recorded. The diseases which prevail are none the less parasitic, the difference exists solely in the temperature and moisture conditions of the atmosphere. Here we must distinguish clearly between the *cause* of the diseases and the *conditions* which favor the given diseases.

Certain parasitic fungi develop more rapidly under cooler conditions than the normal or average while others are favored by higher temperatures; all fungi are favored by large amounts of moisture when these stop short of water immersion and shutting out the needed air. In temperature we have an optimum which usually lies within certain maximum and minimum limits for any given species, but this temperature optimum varies with the organism; it is a matter which admits of exact determination for any organism. As to moisture, an abundant supply of water is the optimum for most fungi with which we deal in plant disease investigations.

In these atmospheric conditions of temperature and moisture the seasons of the year, in our climate, vary one with another. The seasons of heavy rainfall are commonly those of low temperatures by reason of the check on temperatures exerted by evaporation. Further, our weather service records show a tendency for our seasons to come in groups of cooler alternating with groups of warmer seasons; that is, we may have several years as with 1904 to 1907 (excepting parts of 1906) in which the mean monthly temperatures of those months which affect crops were decidedly below the normal or average. Evidently this normal lying as it does between the extremes, is surpassed by the warmer seasons which are said to be above normal. We have likewise, other alternating groups of years in which the season's temperatures are decidedly above the normal.

The effects of these cool seasons upon diseases are most clearly shown in outbreaks of leaf-curl of the peach and plum bladders in early season, and of potato late blight and rot, *Phytophthora infes-*

tans, upon the potato crop. It is understood that plenty of moisture is the usual accompaniment of a cool season; from the combined effect of this supply of moisture and cool weather we have outbreaks of the potato disease.

CAUSES OF PLANT DISEASE.

Non-Parasitic Troubles.
- Atmospheric:
  - Excessive Cold;
  - Excessive Heat;
  - Excessive Dryness;
  - Excessive Moisture;
  - Wind;
  - Hail;
  - Artificial Influences.
- Soil:
  - Deficiency of Necessary Substances;
  - Excess of Certain Substances (Alkali, Salt, Acid);
  - Excessive Dryness;
  - Excessive Moisture;
  - Faulty Physical Structure (Hard-pan, Heavy or Coarse subsoil);
  - Artificial Influences.

Parasitic Troubles.
- Higher Animals (Gophers, Moles, Squirrels);
- Insects;
- Worms;
- Mollusks (Slugs, Snails);
- Higher Plants (Dodder, Mistletoe);
- Fungi;
- Bacteria;
- Slime Moulds.

The above table indicates most of the influences which affect plants injuriously in California, so far as they can be definitely tabulated. It should be further mentioned that, in many cases, various combinations of the above have disastrous results which could not be attributed to any influence acting alone.

DIRECTIONS FOR EXAMINATION OF DISEASED PLANTS.

Before proceeding to a description of the principal troubles of our various crops it may be useful to give the following general directions for the examination of unhealthy plants:

1. Note whether any particular portion of the orchard or field shows the trouble worse or less and, if so, seek to find wherein conditions are different there from those in the remainder of the planting.

2. Note whether any particular kind or variety of the crop is more or less affected than others, also whether any particular individuals show marked resistance, immunity or freedom from the trouble. Ascertain the commercial qualities and desirability of any seemingly resistant or immune variety or individuals.

3. Determine as accurately as possible the part of the plant which is actually affected. In many cases, for instance, the leaves or top

may wilt and die when the real and actual trouble is in the roots.

4. Look first for the simplest effects, such as those of animals, frost or other climatic influences, simple injuries or other obvious causes of trouble.

5. Look for indications of alkali, salt, poor drainage, too light or too heavy soil or other injurious soil conditions, as shown by surface incrustations, the occurrence of native vegetation peculiar to certain conditions or any peculiarity in the appearance of the soil in the region of the affected plants.

6. Look for the presence of fungi, insects or other parasites, so far as one's ability extends in this direction. Endeavor to observe accurately and judge intelligently whether the organisms found are the cause of the trouble or simply secondary.

7. If nothing is found above ground to indicate the cause of the trouble, dig or bore a hole to the depth reached by the lowest roots. During the digging notice the condition of the roots, the consistency of the layers of soil, the amount of moisture which they contain, and their relation to the development of the roots. Look carefully for any peculiar or suspicious condition, either in the roots or soil, and continue the examination out to the smallest roots and down to an ample depth.

8. Ascertain as closely as possible all that can be found out about the previous history and treatment of the soil and plants, all information of possible value as to irrigation practice, fertilization, cultural methods and previous climatic conditions; also the nature of the trouble from its very first appearance.

9. If necessary, examine healthy groves, trees or plants of the same kind, making the same examinations and inquiries, and endeavor to ascertain wherein conditions differ from those where the trees or plants are diseased.

After this examination, if more information is desired, endeavor to select the most characteristic samples, either of parts of the plant or soil, and send them to the proper authority with complete information as to the nature and occurrence of the trouble. In sending parts of plants, pack them so that they will remain as fresh as possible. In obtaining soil samples take a fair sample from each foot down to a depth of four feet.—(Cal. E. S. Bul. 218.)

APPLE, PEAR AND QUINCE DISEASES. APPLE.

Crown-gall, Hairy-Root or Tumors.—On the apple tree this disease appears most often on the trunk and larger limbs, but in a number of instances it has been found affecting the twigs and smaller limbs. The tumors on this tree are exceptionally large at the beginning, and frequently appear in the form of a smooth swelling surrounding the base of a dormant bud, quite often the terminal bud of a twig, and may be noted at the end of the growing season. In the form usually occurring on many other trees, the swellings appear on twigs and limbs indiscriminately, apparently having no connection with the formation of buds. The tumors vary greatly in size on the same and on different trees; some are as small as a pea; others attain a size of 2 to 3 inches in diameter. This variation in size is noted even at the beginning of the formation. Immature tumors are often formed on all portions of the tree, quite frequently occurring at the base of twigs or springing from older limbs or from the trunk. During the first period of their growth the swellings are covered with a thick, fleshy layer of meristem and bark tissues. The growth for the first year or two is often very rapid. At the end of a varying period of time, usually one to three years, depending on the variety of the tree and the conditions of growth in the locality where it is found, the bark covering the tumors becomes ruptured by the rapid formation in the interior of a very peculiar structure; the bark tissue ceases to grow, but the interior tissues develop a structure similar to that found in root formation in the hairy-root disease. As the bark breaks away small elevations, which resemble short thickened root caps, appear on the surface of the tumors, giving them a very warty appearance. The knots now resemble the origin of the formation of the woolly-knot form of hairy-root described by the writer in a lecture to the National Nurserymen's Association last year.

The tumors in their older form in some cases become hollowed out by a slight decay of the tissue in the center, which results either directly from the disease or from the entrance of wood-rotting organisms which are foreign to it.—(U. S. B. P. I. Cir. 3.)

With our present knowledge, therefore, and as a result of the observations and experiments previously mentioned, these tumors on the limbs and trunks of apple trees may be considered the same disease as the woolly-knot form of hairy-root; in other words, they are the aerial form of hairy-root. The simple form of hairy-root, which was described first by Stewart, Rolfs, and Hall and mentioned later by the writer as a form of disease distinctly different from crown-gall, is in the opinion of the writer only a form of the same disease as woolly-knot and these aerial tumors. The simple form of hairy-root occurs most frequently upon seedling trees; it is present both on the stem and root portions of the trees. It consists, when it occurs on the roots, of numerous fine roots growing at right angles from the main roots or the taproot. These side roots are very soft and succulent at first, but later harden and have a wiry appearance and texture. On the roots they are usually quite uniformly distributed in definite belts. Where this form occurs on shoots it springs more frequently from the vicinity of a bud often just beneath it. These fine roots are formed in groups, or bunches, a great many often springing from a single origin. The origin of each of these clumps of roots is similar to that of the rudimentary roots in the aerial tumors. It follows, then, that the hairy-root disease may have at least three forms, which are more or less distinct: The simple, the woolly-knot, and the aerial forms.—(Cir. 3, U. S. B. P. I.)

Root Rot.—This is a reddish brown toadstool, measuring from two to three inches in width. It grows in dense clusters from the crown of living trees and dead stumps. The sphorophores form from September to October. It also produces black subterranean rhizomorphic strands which aid materially in spreading the disease. Wilcox states that this fungus invades the apple, peach and cherry trees.

There are also a number of other organisms which produce Root-rot of fruit trees, but American plant pathologists have given these diseases very little attention. No satisfactory line of treatment can be recommended.—(B. 16, Mo. State Fruit Exp. Sta.)

European Apple Canker.—This disease is reported as serious in the orchards of Europe, and is apparently becoming widely distributed in America. It is not of so common occurrence as the black rot canker, but is more destructive where found. The fungus seems to be dependent upon wounds for entrance to the host tissue. It attacks the inner bark and the cambium, and to some extent the young wood. The mycelium is perennial in the host. As the new growth develops around the wound it is attacked and killed by the fungus; thus a series of ridges may be developed, giving a characteristic appearance to the disease.

Apple Tree Canker.—This fungus is very common on both apple and pear trees and during the past season a number of cankered apple-tree limbs were found on which the injuries were evidently due to its attack. All cankered limbs should be destroyed. Wounds should be thoroughly coated with Bordeaux or paint.—(N. H. E. S. B. 144.)

Blackspot Canker.—This is a disease of the apple tree. In importance it ranks next to the apple scab. It is very prevalent and destructive in Western Washington in localities where the rainfall is considerable during the latter part of autumn and early winter. The disease is caused by a parasitic fungus. The fungus lives in the bark for about a year and then dies. Before it dies it forms spores the greater number of which are distributed from October to late December or a little later. These spores are carried about by the wind and some of them lodge on the bark of apple trees. The moderately low temperature and plenty of moisture usually present in November and later are conditions most suitable for germination. On germinating the fungus enters the bark. Occasionally by the end of a week new cankers make their appearance. They are about the size of a pin head circular, somewhat sunken and nearly black. They increase slowly in diameter but the fungus penetrates the bark into the sap wood beneath. When the tree begins to leave out the cankers increase rapidly in diameter and are mature in size by the last of June or a little later. Mature cankers are usually oblong and vary in size from ¼ of an inch to 6 inches long by ¼ of an inch to 5 inches in width. Frequently they appear to be much larger. As a rule, these larger ones are the result of two or more smaller ones merging together. The cankered bark becomes dry and brittle and separates from the living leaving a fissure. It remains on the tree for a time and then falls out leaving a scar.

About the time the cankers are full grown the epidermis on the cankers become slightly roughened by the formation of pustules just beneath it. Each of these pustules contains numerous spores which when disturbed will cause the new cankers to appear.

Since the spread of the disease is caused by spores and the spores germinate in November it follows the way to prevent the disease is to prevent the germination of the spores. This can be done by spraying the trees with double strength Bordeaux mixture about the first of November to kill the spores on the bark. Under ordinary weather conditions there will be sufficient spray on the bark to kill spores that may lodge on it for a short period of time if the work has been done properly. To catch the spores that are distributed later in the season spray a second time with double strength Bordeaux mixture making the application thorough so that the entire tree is covered with the spray. The second spraying should be done two or three weeks after the first. In rainy weather three or more sprayings may be necessary to keep the bark protected.—(Wash. E. S. B.)

Illinois Apple Canker.—The canker-wounds are usually formed on the large limbs near the trunk of the tree. From here they extend upwards on the limb and frequently down into the trunk. The larger limbs may be attacked higher up in the tree, however. The exact position of the wound depends on the source and manner of infection.—(Ill. B. 70.)

The appearance of the canker varies greatly with age. At first the canker spots are inconspicuous so that they would easily be overlooked by the casual observer. In the earliest stages observed the diseased bark has an unhealthy, dirty brown appearance. It is usually depressed a little below the living bark. The spots vary in size, being sometimes six inches in diameter at this stage. They grow most rapidly in the direction of the long axis of the limb. If the interior of the bark be examined it will be found to have a mottled appearance, due to the interspersion of sound areas bark and portions of the wood laid bare. The dead bark clings tenaciously to the decaying wood. This canker is very common in Illinois. The fungus attacks nearly all parts of the tree from the trunk to the youngest twigs. The bark on the diseased limbs at first assumes a dingy brown color and is closely appressed to the wood. It may remain in this condition for a long time, sometimes until the canker spot is nearly a foot in length. Around the margin of the spot the diseased bark is slightly depressed and is separated from the sound bark by a distinct line and often by a narrow crack. Cracks and rifts appear later over the diseased surface and the bark assumes the dark charred appearance characteristic of the canker.

From the nature of the attacks of *Nummularia discreta* there seems to be no method of curing the injury after the parasite has once gained entrance into the limb. The mycelium extends through the wood some distance beyond the injured spot. It is thus well protected within the heart-wood of the tree. If the canker is found in its first stages, however, it may be useful to cut away the injured bark and a portion of the wood and keep the wound covered with Bordeaux mixture or paint. The bark at the edges of the wound will grow out and heal over the injury. Limbs which have extended diseased areas should be removed and burned. When a limb is badly injured it is so weakened that the fruit borne on it is of little value and the death of the limb is only a question of time. Meanwhile every diseased spot is a source of danger to the orchard and cannot be too quickly removed. The canker spots frequently occur near the trunk so that the life of the tree is endangered by them. Infections through wounds caused by pruning can be to a great extent prevented by careful attention to the details of the operation. The indiscriminate and careless cutting of branches frequently practiced in this state is detrimental to the health of the tree aside from the opportunities it offers for parasites of all kinds to enter. Long stubs should never be left on the tree. Limbs should be cut close to the parent branch without making the wound unnecessarily large. Wounds caused by proper pruning heal without difficulty. They should be kept painted or covered with Bordeaux mixture. Injuries caused by climbing about in the trees can be prevented entirely by picking from ladders. There is rarely any necessity for climbing the tree to pick the fruit. —(Ill. E. S. B. 70.)

New York Apple Tree Canker.—Any part of the tree above ground, with the possible exception of the leaves, may be attacked by the canker fungus which has been proven to be *Sphæropsis malorum* Pk. When the larger limbs, or in rarer instances, the trunks, are attacked, the injuries are known as cankers. Such injuries are often quite conspicuous since the bark becomes thick and rough, and saprophytic fungi soon gain a foothold causing the parts to turn black. The injuries are often several feet in length; and because of these striking characters, cankered limbs may be recognized at a considerable distance.

The fungus may live in the outer bark but here it does little harm and true cankers are formed only when it gains entrance to the cambium layer. Under favorable conditions the fungus spreads until a considerable area of bark is destroyed. The limb may be girdled by the fungus but borers and saprophytic fungi often complete the work of destruction. An affected branch may live for a number of years and bear fruit but if the wound is large the normal activity of the branch is seriously interrupted. The swelling of the bark is probably caused by an excess of food being deposited, as a result of the partial girdling of the limb.

When the twigs are attacked a portion of the new growth may be killed in much the same manner as when attacked by pear blight. Much damage may result from such attacks and the fungus may occur in orchards where there is no evidence of cankers on the larger limbs. The longitudinal areas of reddish bark often seen on the south and southwest sides of trunk or limb are an indication of sun-scald. The tissues of this discolored bark have been killed by sun and frost. At the approach of warm weather, fermentation may set in and a sour odor be given off from the affected parts.—(N. Y. [Geneva] S. B. 185.)

Leaf-Spot Diseases.—There are several species of fungi that attack apple leaves, producing brown, circular spots that range from mere specks to spots one-fourth of an inch in diameter and in some cases much larger. The disease may begin to appear in the spring soon after the young leaves unfold, but the spots are usually more prominent between midsummer and the end of the season. This diseased condition causes the leaves to drop prematurely, frequently leaving the trees denuded in early autumn, six weeks or two months before the normal period of leaf fall. Trees thus deprived of their foliage cease activity, and as a result the fruit is small and not properly matured; the buds for the crop of the following year are weakened and in some cases not fully developed, and the life of the tree is materially shortened. These leaf diseases are partly responsible for the failure of the trees to produce crops and for the early decline of the orchard.—(F. B. 283.)

Leaf spots are due to several different fungi, perhaps the most prominent of which is a species of Phyllosticta. A species of Hendersonia and the ordinary black-rot fungus, *Sphæropsis malorum,* are found in connection with some of these spots and may be responsible for the injury in some cases. Other fungi are also frequently present in the dead areas, and it is not always clear which are the real parasites.

One of the most striking results of spraying an apple orchard is the effect on the foliage. These leaf diseases are largely prevented by applications of Bordeaux mixture, and the foliage remains fresh and green long after unsprayed trees are defoliated. This was true of all the demonstration blocks in the Ozarks during the past season. The unsprayed trees began to shed their leaves in July and were practically defoliated by the last of August, a month before the time to pick the crop.

The treatment recommended for bitter-rot and apple blotch will largely prevent these leaf troubles and hold the foliage in good condition until frost. It is true that some of the leaves become affected soon after they unfold in the spring, but the trouble does not usually become serious before midsummer, and the four applications of Bordeaux mixture for bitter-rot at intervals of two to three weeks, beginning about six weeks after the blossoms are shed, appear to give reasonable protection. However, the earlier applications usually necessary for the control of apple scab and the codling moth aid in the control of leaf-spot diseases, and when these are made, only one or two of the later sprayings are necessary. When it is desired to spray for leaf-spot diseases only, the first application should be made about two or three weeks after the petals have fallen, and a second about seven weeks later. These two applications, if thoroughly made, will usually hold the foliage in good condition.

Brown Spot, Frog Eye.—From a commercial standpoint this disease is more injurious to the foliage of the apple than either the blight or scab fungus. The attacks of this enemy are entirely confined to the foliage of the tree. But its work is none the less to be dreaded on that account, for anything which lessens or interferes with the leaves or their functions affects the most vital portion of the plant.

When seriously affected the trees appear as though the leaves had been parched and blanched by the sun, but close inspection shows that the diseased areas are more or less localized and that the first indications of the disease are small brownish red spots which gradually enlarge, the center becoming lighter in color, and finally two or more diseased areas may run together forming a large irregular dead patch of tissue. Luckily this disease is more amenable to treatment than the Rust. In fact if the orchard is thoroughly treated with Bordeaux Mixture for the Scab there will likely be little or no injury from the Brown Spot. If untreated however, the disease may cause a serious loss as it works early in the season often causing the foliage to fall in July. It may and usually does appear again in August or September and when this occurs the foliage falls early, before the fruits are grown and colored. Injury at this stage produces loss of flavor, lack of color, and improper maturity and probably a poorer-keeping product.—(W. Va. E. S. B. 66.)

Apple Mildew.—Podosphaera oxyacanthae. It attacks water sprouts, young twigs and leaves. It is most frequently found on nursery stock. It forms a powdery-whitish surface which later becomes a dirty white. When abundant on the leaves it causes them to roll up and occasionally to fall off. The disease can be controlled by the use of either Bordeaux mixture or potassium sulphide.—(Wash. E. S. B. 70.)

Bitter-Rot.—This is one of our most destructive diseases. It most frequently appears on the fruit usually during the months of July and August; still it has been observed as early as June 25th. The time of its first appearance varies with climatic conditions of the season. The first spots often develop on fruit when it is about half grown, and the disease usually continues to spread with increasing severity until the crop is harvested. Warm, sultry weather following a rain forms an ideal condition for the development of this organism. In cool, dry summers the disease develops sparingly. A few hot, wet days in August may bring on a very sudden and destructive attack. Nights with very heavy dews alternating with hot days may also cause the rapid development of this organism and often cause the complete destruction of a promising crop in a few days. Cold weather soon checks its development. When the fungus attacks the fruit small light-brown spots appear, which increase rapidly in size. These spots soon take on a dark brown color, and their borders are usually circular in form. While quite small they become sunken, the tissue being soft and bitter to the taste. Small black dots appear usually at regular intervals beneath the epidermis on the sunken spots. These black bodies increase in size, and soon give off a large number of spores. These spores often exude in the form of minute pink threads which are quite sticky when moist. As the disease advances in the tissue of the apple, these black bodies are often arranged in form of rings. If the weather is unusually favorable for the growth of such organism, as high as nine or more of these rings may form in rapid succession. Unfavorable weather retards the growth of the fungus and tends to produce an irregular development of these black postular rings. The pinkish appearance of the diseased area on the apple is due to the spores oozing out of these black bodies and forming in large masses on the skin of the infected areas. The size of the diseased areas usually increases rapidly, and two or more separate infections may join, but the apple seldom decays entirely. Some of the cells remain firm a long time. When fruit is completely rotted it mummifies and often remains hanging on the tree. Usually, however, infected apples fall prematurely. This fungus also invades the tissue of the limbs and produces rough, black wounds, known as cankers. These wounds usually occur on last year's fruit spurs and smaller limbs although the larger limbs and even the trunk may be invaded. Both winter and summer spores are formed in these wounds. Such wounds frequently develop at the base of infected fruits.

Four applications of Bordeaux mixture, at intervals from two to three weeks will control the disease. Mr. W. M. Scott (U. S. Dept. Agr., Farmers' Bulletin 283, p. 18.) recommends that the first application be made six weeks after the petals fall. The second should follow the first within two weeks, while the intervals between the subsequent applications may be extended to three weeks unless the season be unusually wet and warm.—(Mo. State Fruit Exp. Sta. 16.)

*Apple Blotch.**—This is one of the most serious diseases of the apple. It is of comparatively recent discovery, as it was first reported on apples in 1902 and not until 1907 was it known to be serious. On the apples, at first, the very small spots are light brown and look somewhat like a cluster of dark fibres just under the skin. As the spot grows it becomes darker and has a very ragged and fringed edge. Several spots may run together to make a large blotch. The spots are not deep in the flesh of the apple, but often cause cracking. On different varieties they vary somewhat in appearance. The older spots are often dotted with black raised dots, which do not bear spores as a rule.

On the leaves the spots are very small, sunken and pale. They are not conspicuous and are easily overlooked. On the twigs this disease makes small, rough cankers, which often encircle the twigs. Only rarely are the cankers large enough or deep enough to do serious damage to twigs or limbs. The principal damage is to the fruit, which is spotted so as to be unsalable as fresh fruit, and if the disease is very bad it does not peel easily and is undesirable for evaporating. From all the studies made so far on this disease it seems that it is spread from the twig cankers entirely. It begins to spread to the leaves and fruit from a month to six weeks after the blossoms have fallen. It seems to spread in moist weather more than in dry.—(Ark. E. S. Cir. 7.)

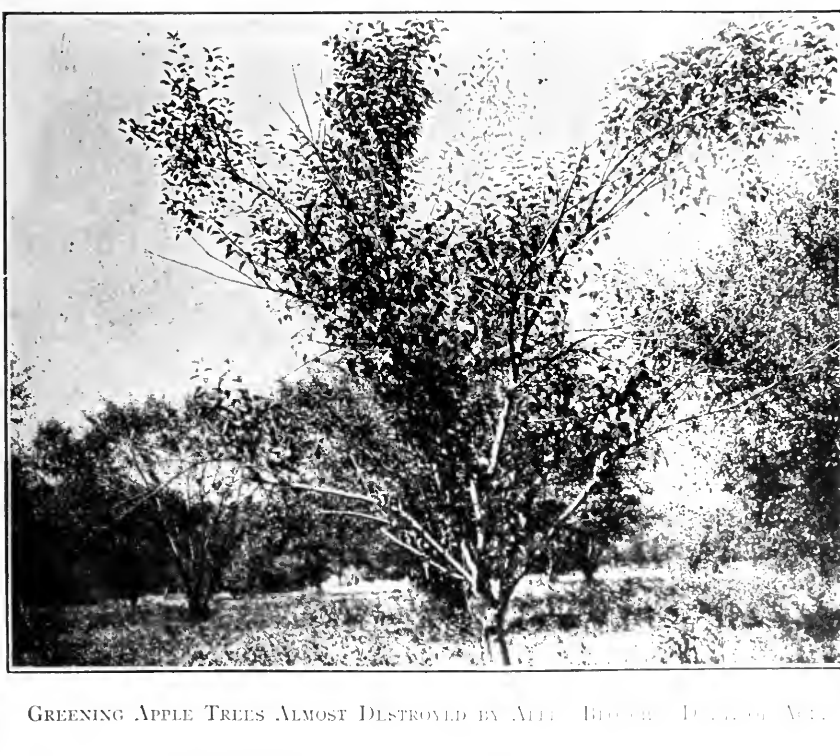
TREATMENT FOR APPLE BLOTCH, ETC.

The treatment for apple blotch conforms closely to that for apple bitter-rot and with one or two additional applications all the other important fruit and leaf troubles may be controlled. The following course of treatment is therefore recommended for orchards in southern sections, especially where apple blotch and bitter-rot occur.

First Application.—When the cluster buds are well out, just before the blossoms open. This is the first treatment for apple scab and is of special importance for badly scabbing varieties, such as the Winesap, Arkansas, Arkansas Black, and Red June. It may be omitted from the Ben Davis, Gano, Jonathan, and York Imperial, which scab

* See page 267 for illustration.

A Power Spraying Outfit in Operation. Dept. of Agr.



Greening Apple Trees Almost Destroyed by Apple Blotch. Dept. of Agr.

very little or not at all in most southern sections. This application also constitutes the treatment for the spring canker worm.

Second Application.—Immediately after the petals fall. The work may be commenced when about two-thirds of the petals have dropped and should be finished within a week or ten days, that is, before the calyx lobes close. This constitutes the second application for scab and the first for the codling moth and is the most important treatment for both.

Third Application.—Three to four weeks after the petals have fallen. This is the first and most important application for apple blotch and is the second treatment for the codling moth.

Fourth Application.—Eight to nine weeks after the petals have fallen, or not later than June 25. This is the first treatment for bitter-rot, the second for blotch, and the third for the codling moth.

Fifth Application.—Two to three weeks after the fourth application. This is the second treatment for bitter-rot, the third for blotch, and is also important for the codling moth.

Sixth Application.—Three weeks after the fifth application. This is the last treatment for bitter-rot and blotch and is important to prevent late infections. It is also very important for the control of the second brood of the codling moth.

The course of treatment given above is intended for the control of all the important apple troubles, such as scab, bitter-rot, blotch, leaf-spot, codling moth, and canker worm.—(B. P. I. B. 144.)

Black Rot, Canker and Leaf Spot.—The three diseases given above have been found to be due to a single fungus, *Sphæropsis malorum.* The black rot of the apple is very common in New Hampshire. It is dark brown or black in color and the affected tissue comparatively firm. It is thus readily distinguished from the soft rots. It may start on any part of the fruit, but often begins at the blossom and frequently follows insect stings. The disease is primarily a rot of ripe fruit, but it may often be found as dark brown spots ⅛ to ½ inch in diameter several weeks before the apples are mature. These spots may develop very slowly until about picking time, but after that spread rapidly to involve the whole apple. As the rot develops, numerous minute, black elevations may be seen on the apple. These are the spore producing bodies of the fungus and are known as pycnida. The rot does considerable damage in cellar storage, but is especially common on the fruit left on the trees or ground. This worthless fruit becomes a great source of infection the following spring. Sprayings made at various times in the summer have had little or no effect upon the number of spots of rot on the fruit at picking time. The destruction of the affected fruit is apparently the only efficient treatment for this form of the disease. All cankered limbs should be cut out and burned. Proper treatment of wounds and thorough spraying will decrease the number of cankers. Heavy applications made when the trees are in a dormant condition are probably especially efficacious.—(N. H. E. S. B. 144.)

Fruit Spot of Apples.—This disease is of very common occurrence in New Hampshire and is found as far south as Maryland and

Virginia and as far west as Michigan. It is not so destructive as the scab, but often causes otherwise perfect fruit to go as seconds. It is found on almost every variety of apple, but the Baldwin is especially susceptible. The disease appears about the middle of August. At this time it may be seen as spots of a deeper red on the colored surface of the apple and of a darker green on the lighter portion. As the season advances, the spots become more prominent. They usually become slightly sunken, and on the red surface the color often changes to brown or black. The tissue beneath the spot is rendered brown and corky to a depth of several cells. Cold storage seems to check the development of the spots, but in cellar storage they often become more sunken and spread deeper into the tissue of the apple. —(N. H. E. S. B. 144.)

The disease is readily controlled by spraying. Applications two and three as given for apple scab will practically prevent the disease. However, if these sprayings are to be given for fruit spot alone, it is advisable to make them about ten days later than the dates given for scab. Both Bordeaux and lime-surphur have given satisfactory results.

Fruit Pit.—The disease variously known as Fruit Pit, Baldwin Spot or Bitter Pit is not of so common occurrence in New Hampshire as the fruit spot, yet is sometimes quite serious on certain limbs and trees. It is found in various sections of the United States and Canada and is considered a very serious disease in Australia and South Africa.

It is somewhat like the fruit spot in appearance, and has been sometimes confused with it; yet is distinctly different upon close observation. In the early stages of the disease the spots may show no difference in color from the surrounding portions of the apple and only the slightest depression. At this time they have the appearance of numerous minute bruises. They soon become conspicuous as sunken areas from ⅛ to ¼-inch in diameter. The depressions are somewhat hemispherical in shape. As they continue to develop they become more highly colored than the surrounding portions and later take on various shades of brown. At first this coloration shows through from rather deeply seated tissue, but later the surface tissue also becomes a dark brown. As the disease advances, the spots situated near each other often become confluent, developing into one large spot or pit. The pronounced depressions in the later stages of this disease are characterized much better by the term *pit* than by that of *spot.*—(N. H. E. S. B. 144.)

Pink Rot.—When the scab fungus itself first takes hold of the apple, it grows beneath the skin, and as it matures, the skin is ruptured and the edges left somewhat upturned. It is near the upturned edge that the pink fungus so often makes its beginning, forming a ring of mould. The entire scab spot however, is usually covered with a white mould. This gradually changes to a pink or rose color. This color is due to the entire spot becoming dusted with the pale rose-colored spores.—(N. Y. [Ithaca] E. S. B. 207.)

This fungus is very characteristic in its appearance on the apple. It is frequently called by fruit-growers the pink fungus, from the color of the spots as the fungus matures.

If we examine an apple affected by this disease in its more advanced stage, we notice one or more pink spots which are usually more or less circular and sunken. Around the fungus and in the edge of the sunken portion, the skin is brown. If we examine these spots at an earlier stage, we will usually find a circular white patch of mould, or still earlier, perhaps a ring of mould about a darker scab spot.

The first change in the appearance of the apples, is that the skin or epidermis turns brown around the spots. This gradually extends out in all directions so that the various spots merge into each other, covering large areas, or the entire surface of the apple. As the spots increase in size, they also sink. The sinking may be due not only to the dissolving of the solid parts of the apple by the fungus, but also to the evaporation of water through the spots. Not only does the skin of the apple in the edge of the sunken spot turn brown, but the flesh beneath is similarly colored, and is bitter to the taste.—(N. Y. [Ithaca] E. S. B. 207.)

Apple Rust.—Apple rust is a widely distributed disease, and in some sections is quite injurious. It is of common occurrence in New Hampshire and, while not one of the most serious apple troubles, it often does considerable damage. It sometimes attacks the fruit, but its effects are usually confined to the foliage. Here it causes yellowish spots, which usually become somewhat elevated in the center and in which are produced numerous spores. The spots usually appear on the leaves in June. The spores from the leaves are borne by the wind and attack the twigs of cedar trees, causing morbid growths or swellings, the so-called cedar apples. The fungus passes the winter in the tissue of the cedar apple and in the spring produces an abundance of spores in the gelatinous outgrowths of these galls. These spores, when borne back to the apple foliage, produce the rust again, and thus the fungus passes from one host back to the other.

Numerous efforts to control the disease by spraying have been without success. Since the cedar apples harbor the fungus through the winter the method of control is obviously to destroy them, or, when practicable, the cedar trees themselves.—(N. H. E. S. B. 144.)

Sooty Blotch and Fly Speck.—The sooty blotch and the fly speck of the apple were formerly thought to be caused by two different fungi, but the recent work of Floyd indicates that both are due to the fungus indicated above. The names given these two effects characterize their appearance. The former produces blotches ⅛ to ½ inch in diameter on the fruit and the latter numerous minute specks. They give the apple a sooty appearance that depreciates its market value. The fungus growth is entirely on the surface of the fruit, and hence the disease is especially dependent upon moist weather for development.

The disease is readily controlled by spraying. Thorough pruning is important, and if light and air have free access to the fruit the disease usually gives little trouble.

Apple Scab.—The disease appears first on the leaves. Here it may be evident early in June as slightly elevated spots of a lighter green color. At this stage the mycelium of the fungus is largely beneath the cuticle. It soon breaks through to the surface, giving the leaf a velvety, olivaceous appearance. Spores are produced in abundance and probably serve as the chief source of infection for the fruit. As a result of the fungous attack the leaves often become distorted and finally fall early in the season.—(N. H. E. S. B. 142.)

It is on the fruit that the fungus produces its most characteristic and serious effects. Here it forms superficial olive colored spots known among apple dealers as scab, fungus or black spot. The spots are usually 1/8 to 1/2 of an inch in diameter. The mycelium begins its development beneath the cuticle, but soon sends up erect sporophores (spore stalks), which break through to the surface to free their spores. The spores and sporophores give the spot its sooty, olivaceous appearance. The marginal portion of the ruptured cuticle usually remains, giving the spot a light gray border. The fungus checks the growth in the adjacent tissue to such an extent that apples attacked early in the season often become dwarfed and one-sided, and sometimes badly cracked.

The disease can be controlled by spraying. To be most effective the spraying must be made before the fungus has gained entrance to the host as when it is once beneath the cuticle it may continue to develop in spite of the application of fungicides. In badly affected orchards it is advisable to make a spraying before the leaves are out. At this time copper sulphate, 1 pound to 25 gallons, may be used, or a strong Bordeaux or lime-sulfur solution. The first regular spraying should be made after the leaves have expanded and before the flower buds open. Bordeaux or lime-sulfur may be used for this and for later applications. The second spraying should be given when most of the petals have fallen. This application is the most important of the season. When the disease is at all serious two more sprayings are needed, the third about three weeks after the second and the fourth early in August to prevent a late spread of the disease. —(N. Y. E. S. B. 142.)

Spray Injury.—Injury from Bordeaux mixture is of quite common occurrence. On the leaves it appears first as purplish brown spots of various shapes and sizes. They are usually smaller, more irregular in shape and more thickly distributed on the affected foliage than the leaf spot previously described. Soon after the appearance of these spots the leaves may begin to turn yellow. Leaves so affected soon fall, and in serious cases the trees may be almost entirely defoliated. Such extreme cases, however, have been very rare.

On the fruit the injury appears first as small, black or brown specks scattered thickly over the apple. Later in the season the skin may become corky and russeted. In serious cases the apple may be much roughened and deformed, and large, deeply-sunken scars develop. The slightly affected fruit may almost entirely outgrow its injuries by picking time, but when the injury is very great the fruit may drop before maturity, and in any case is of little commercial value.

Spraying for Apple Diseases.

No.	Application.	Fungicide.	Purpose.
1	Before buds open.	Bordeaux 6-6-50 or copper sulfate 1-25 or lime-sulfur 1 to 11. Lime sulfur should be used in orchards having San Jose Scale.	Gives antiseptic treatment to any small wounds not otherwise cared for. Destroys any spores of scab, leaf spot, etc., that may have reached the tree by this time.
2	After leaves expand and before flower buds open.	Lime sulfur 1-30 or Bordeaux 3-3-50.	For apple scab. Most important application for leaf spot.
3	When flower buds have mostly fallen.	Lime-sulfur 1-30 or Bordeaux 3-3-50. An insecticide should be added for the codling moth.	Most important application for apple scab.
4	Three weeks after third application.	Lime-sulfur 1 30 or Bordeaux 3-3-50. An insecticide should be added for the codling moth.	For apple scab and fruit spot.
5	Two or three weeks after 4.	Lime sulfur 1-30 or Bordeaux 3-3-50.	For fruit spot. May be omitted if earlier sprayings have been made.
6	First or second week in August.	Lime sulfur 1-30 or Bordeaux 3-3-50. An insecticide may be added for the brown-tail moth.	To prevent late spread of apple scab.

—(N. H. E. S. B. 144)

The most serious injuries have been obtained from the early sprayings. This may be largely due to the fact that showers are common at that time of year. It is a well-known fact that when an application of Bordeaux is followed by rain within the next few days it is likely to produce injury. Records from a large number of cases of Bordeaux injury in New Hampshire would indicate that damage seldom, if ever, occurs in properly sprayed orchards except under the above mentioned conditions.

The injury done by Bordeaux has not been great enough to offset the good accomplished, and various commercial growers have annually obtained large profits from its use, yet the condition has been serious enough to make strong demands for a solution of the difficulties. The matter has been taken up at various experiment stations, including those of New York, Illinois and New Hampshire, but a complete solution of the problem has not been found.

Much trouble may arise from the use of improper mixtures and from unsatisfactory methods of application. Only good material should be used, and the following of the directions for making the solution is important. The liquid should be applied to the tree as a fine mist and never allowed to sprinkle or drip from the nozzles. The foliage must be thoroughly covered, but dripping from the leaves indicates an excessive or careless application. Mistakes are often made by trying to spray with insufficient power. A pressure of 70 pounds is essential, and one of 100 pounds or over is very desirable.

In looking for a solution of the problem various kinds and strengths of Bordeaux have been tested. While weaker solutions may produce less injury, they do not obviate the trouble. The use of an excess of lime has had little or no effect upon the amount of injury. The 3-3-50 formula seems to produce as little injury as any, and is most satisfactory for the majority of apple diseases. The patent Bordeauxs which are on the market have not been shown to be any less liable to produce injury than the home-made mixtures, and many of them have proven quite inefficient in controlling diseases.—(N. H. E. S. B. 144.)

Other Apple Diseases.—Brown Rot—(See page 476); Pear Blight—(See page 464); Texas Root-Rot—(See page 602).

QUINCE DISEASES.

Anthracnose.—The fruits and possibly the branches of quince are attacked by an anthracnose fungus (*Glomerella rufomaculans*) which is the same as that causing bitter-rot in apple. According to our knowledge of the survival of this fungus, attention must be given to gathering and burning of mummy fruits and to the cankers produced, if any, upon the branches. The spraying treatment necessary is the same as that for apple bitter-rot.

Black-Rot.—The fruit and foliage of the quince are attacked by black-rot. The black-rot multiplies very rapidly in the fruit of quince and often causes loss of much of that produced. This fungus (*Sphæropsis malorum*) also develops as a leaf-spot upon the foliage causing defoliation. It is liable to attack the branches after the manner determined for apple. To hold this fungus in check very careful spraying is required at times, but as a rule it is easier to keep down the black-rot on fruit and foliage of quince than to keep it down on susceptible apples. The spray used is Bordeaux mixture.

Leaf-Spot.—This is identical with that upon pear, and is found at times formed upon the quince. It is controlled by the same treatment as the black-rot.

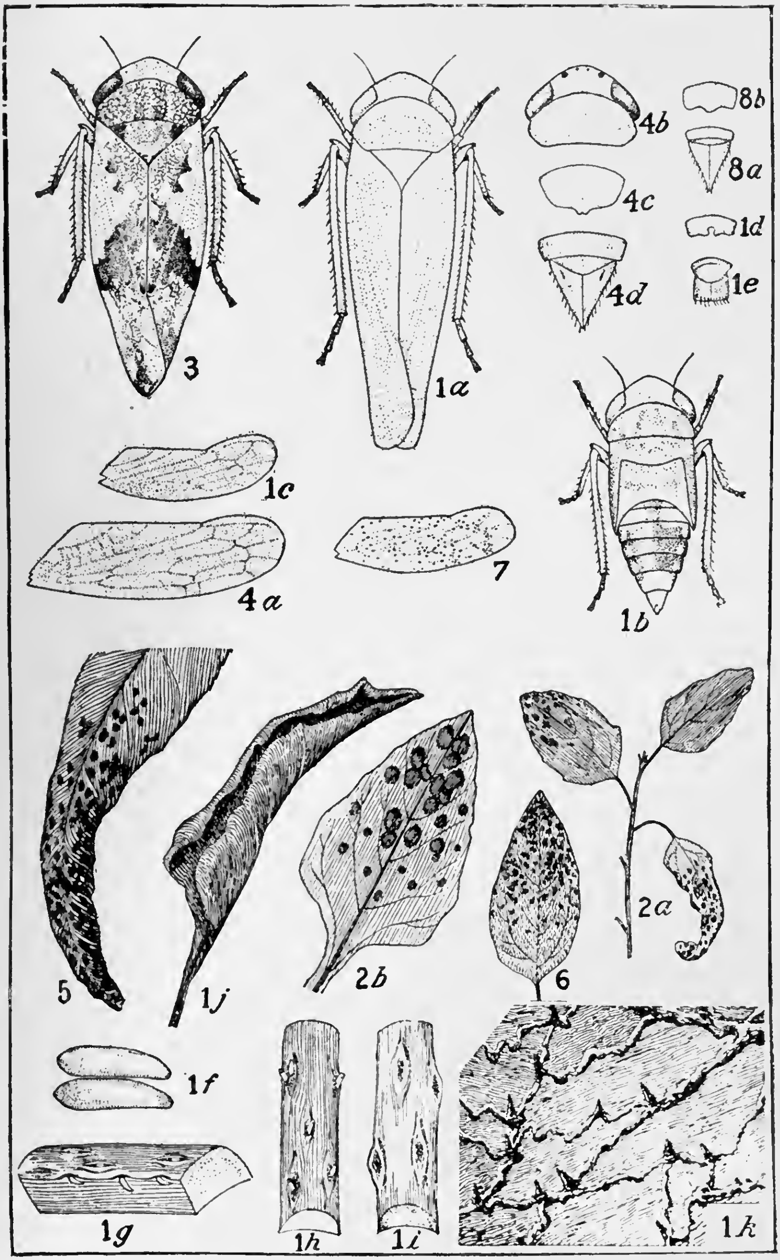
Blight.—The blight upon quince (*Bacillus amylovorus*) is slightly less destructive than that upon pear. It is caused by the same bacterium and requires the same watchful care and attention as in the case of pear.

Pale-Rot.—This (*Phoma cydoniæ*) is reported from some of our states and may occur in Ohio. There is no evidence to indicate that it will require more prolonged treatment than black-rot or leaf-spot.—(Col. E. S. B. 218.)

Other Quince Diseases.—Cankers—(See pages 453-455 and 459); Bitter Rot—(See Apple); Rust—(See pages 453-455 and 459).

PEAR DISEASES.

Pear Blight.—The disease usually attracts most attention in the spring about three weeks or so after the blossoming period, when many of the flower clusters shrivel and die and the infected



Leaf Hoppers and Their Work. Dept. of Agr.

twigs blacken and dry up as if scorched by fire. Usually blossom blight accounts for a large per cent of the infected points, still occasionally twig infection exceeds blossom infection. If the season or conditions are unfavorable for the growth of the organism it may run only an inch or two on the branch or fruit spur and stop. But if the conditions are favorable for the growth of the organism it may cause vital injury. The organism may finally run down into the thick bark of the larger branches and continue to develop during the entire growing season, frequently producing serious wounds on the limbs. These wounds may be extended down the limbs into the body of the tree and finally reach the ground. This disease advances in various irregular ways and it is impossible to know just what form the infected area will assume. A blighted fruit spur may produce a circular spot an inch or two in diameter on the limb, frequently, however, such wounds are extended from the lower side of the injury, forming a strip of diseased tissue down the side of the limb, often making it difficult to save the limb. Such wounds are usually soon invaded with various wood destroying fungi, forming large wounds or cankers which weaken the vitality of the tree. The amount of injury done by the organism after it gains entrance to the tissue of the tree depends much upon the condition of the tree. A well-nourished tree which is making a vigorous sappy growth suffers severely from blight. The older slow growing trees blight less severely than young vigorous trees. Conditions which favor large crop productions usually furnish the most favorable surroundings for the development of this organism.

Treatment.—From the nature of the disease it is plain that it requires the combined effort of a community to control it. In the older orchards where the organism is well established it will require the most persistent effort to get it under control. However, in the younger orchards or where the disease has not become thoroughly established it will yield to the following treatment; this treatment is also successfully used in controlling this organism on the apple, apricot, plum and quince: Cut out very carefully and thoroughly all the infected tissue in the fall and winter, being constantly on the lookout for the irregular developed cases where disease extends down much further on one side of the branch than the other. The diseased limbs in the top of the tree at ends of the branches are usually readily seen, but the infection on the larger limbs which are covered with rough bark and on the body of trees are frequently very difficult to detect. A dead water sprout usually indicates an infected area and gum exudate occasionally shows the location of some of the obscure cases. The infected branches should always be removed several inches below any signs of discoloration and the wound on the tree disinfected with some strong disinfecting solution. In extreme cases where the disease has infected considerable tissue on the trunk of the tree, it is almost impossible to save the tree and it is usually best to cut down and burn such trees.—(Mo. State Fruit E. S. Cir. 3.)

Leaf Blight of Pear.—This disease has long been known to horticulturists as the leaf blight or scald of pear and as the cracking of the fruit. It occurs practically wherever the pear is cultivated. It was mentioned in this country early in the sixties. The prominent symptoms are the premature discoloration of the leaves and their falling off together with the frequent cracking of the fruit. This leaf fall may be sudden or more gradual, extending in the latter case throughout the growing season. Often the leaf fall is accompanied with a second blossoming—both together making a rather severe drain upon the food supplies of the tree.

Small reddish spots are first seen upon the leaves; these spots as they increase in size take upon themselves a more definite circular shape. At maturity the spots are provided with a white to reddish brown center and a darker raised border. The spots may unite with each other and thus the whole leaf may become affected. The spots may come to be seated upon a reddish brown discolored leaf or the leaf may turn yellow. In any case the leaves fall from the tree.

In many cases there is also a so-called cracking of the pear produced by the same fungus. Small reddish spots appear upon the fruit and these spots may rapidly increase in number and finally coalesce with one another to give the fruit a very much blotched appearance that will greatly reduce its market value. At the same time the growth of the spots may be accompanied by a cracking of the fruit and of course this cracking may make an entrance for the spores of the rot fungi that may cause much damage. The same fungus often attacks the young twigs of the pear. The spots upon the green bark of these twigs are somewhat elongated, sunken and of a black color. In each of the spots referred to above on either the leaves, fruits or twigs one may see one or more blackish spots just beneath the surface. These spots are the spore producing bodies of the fungus. The petioles and leaf scales are also frequently attacked.

Fallen leaves should be gathered together and burned. The disease may be controlled by spraying with Bordeaux mixture, as follows:

(1.) When leaves are half grown.
(2.) Three subsequent sprayings at intervals of two weeks.

The sprayings after the second should be made with an ammoniacal copper carbonate to avoid the russeting injury to the fruit often produced by the Bordeaux mixture.

Scab.—The scab of pear is, like the similar disease of apple, very widespread and well known. It is known from practically every region where pears are grown. The symptoms are practically the same as for the apple scab. This disease is due to the fungus called *Fusicladium pirinum.* The diseased leaves should be plowed under or else gathered together and burned during the fall. Two sprayings with Boreaux mixture of the 1-10 formula should be made while the pear leaves are opening. Considerable good in controlling pear scab will result from a spraying with the lime-sulphur-salt mixture as late in the winter as possible.—(Ala. E. S. 132.)

Pear Scab.—A scabby, corky growth in certain spots on the surface, accompanied by a distortion or deformation of the mature fruit, is the main feature of the disease. Scabby pears are perfectly sound and of normal texture and flavor except in the affected parts. The scab growth is very superficial, affecting only the outer surface tissues, which are hard and corky. Such fruit is perfectly healthful and in no way injurious because of the disease, yet on account of their poor appearance, color, and shape, pears which are badly scabbed are almost entirely useless for any purpose, while if at all seriously affected they are worthless for shipping, undesirable for canning, and poor for drying. In years of abundant pear scab unsprayed orchards have shown losses of from one-fourth to nearly all the crop in marketable pears. The velvety growth on the surface consists of numerous erect threads, which grow up from the surface stratum. At the ends of these threads the oval-shaped *spores* are produced, which drop off very readily and serve to distribute the fungus. These spores are capable of sprouting when moisture reaches them, and starting the fungus anew. Pear scab fungus also develops upon the bark of the young shoots and twigs of the tree, as well as upon the fruit and leaves, though here it is inconspicuous and not as readily observed as in the latter situations. This fact is of particular importance in combating the disease.

The usual recommendations for pear-scab treatment, published in bulletins and spray calendars of the various State experiment stations, call for spraying with Bordeaux mixture just as the buds expand, again after the blossoms have fallen, and a third time about two weeks later. This refers to spraying for scab alone, without reference to insect pests. In California the spraying of pears for scab has been largely along the line of general treatment for the eradication of all pests, definite or indefinite. To clean up the tree is a popular expression of the object of most pear-tree spraying, except the use of paris green for worms. More definitely stated, the usual practice of pear spraying consists in treatment with lime-sulphur in January for scale, scab, moss, softening the bark, and a general clean up. This is applied by some every year, by others once in two or more years, and in still other cases not at all. Beyond this two or three sprayings with paris green and lime are made in summer after the fruit sets, adding bluestone for scab and general results.

The results of this treatment have not been entirely satisfactory in relation to scab control. While the disease has varied in abundance from year to year, orchards sprayed in this way have shown much scab in years when it was abundant and considerable losses have resulted. Neither the early-winter lime-sulphur treatment, or the summer paris green, bluestone, and lime spray, or the combination of the two, has shown decidedly satisfactory results in scabby seasons when closely followed up, although such treatment has been better than none at all.—(Cal. E. S. B. 163.)

Crater Blight.—This term is a rather common one among pear growers, but is not applied to any very definite form of disease. It is supposed to signify a dying of certain spots or patches of bark situated on the limbs or trunk. In these patches the bark becomes rough on the outside and dark colored beneath the surface. Some injury of this sort appears to be connected with the disease described above, the bark dying in certain spots rather than in a strip up and down the whole length of the branch or trunk. True pear blight may also cause a similar effect by running in from a small shoot or fruit spur, but many cases of both black leaf and crater blight occur without the presence of the pear blight organism. Frequently, what is called crater blight is really nothing more than the normal roughening of the bark of the pear tree as it grows older. In this tree the bark begins to crack and roughen in patches on the trunk and main limbs, and its normal condition has sometimes the appearance of the outbreak of some disease.

Curly Bark.—This is somewhat similar to the above, the bark cracking in concentric rings in spots upon the surface of the main limbs. It is not of any serious consequence.

Fruit Drop.—The young fruit drops from the tree while still very small and immature. Due to imperfect pollination. Ordinarily results simply in a desirable thinning of the fruit, but sometimes a large part of the crop drops from this cause. May also be produced by frost affecting the fruit soon after setting. Such fruit may remain on the tree and continue to grow for some time after the frost occurs before falling.

Ringed Fruit.—Some years many pears are found at maturity with a scabby ring or belt of considerable width extending around the fruit. The pears are constricted in this portion, owing to interference with the growth. It is evident that this effect comes about through some injury to the pear when it is quite young. This is a frost effect, and pears in a very small, young condition may be seen with similar rings about them in a season when much damage has been caused by late frost.

Bitter Rot—(See page 457); Powdery Mildew—(See page 457); Leaf Spot—(See page 455); Black Rot—(See page 459).

DRUPACEOUS FRUIT DISEASES.

DISEASES OF ALMONDS.

Shot-Hole.—There appear on the leaves numerous small, dead spots, which finally fall out, giving a shot-hole effect. The young twigs are also spotted. The trees are sometimes defoliated early in the season by this fungus and the crop badly injured. Spray with Bordeaux mixture in the spring as the buds are opening.

Rust.—Red or brown, dusty pustules appear on the under side of the leaves, usually late in the season. The fungus may hasten the normal dropping of the leaves somewhat but is not serious on thrifty trees; worse where the trees suffer from drouth. No treatment ordinarily needed.

Root Rot—Oak Fungus.—Many orchards of almonds and other trees contain certain spots where the trees commence dying from a center, the trouble gradually proceeding outward in a circle, involving tree after tree. Clusters of toadstools frequently appear about the base of affected trees in the winter. These spots usually coincide with places where oak trees formerly stood and the destruction of the fruit trees is due to certain toadstool fungi which apparently live on the old oak roots and spread through the soil, infecting the roots of the orchard trees. Several different fungi seem to cause this disease, among which *Armillaria mellea* is probably the most important. The progress of the trouble may be checked by digging a deep trench around the affected area, but this is impracticable in most cases. The development of a resistant root presents the only practical remedy. The pear root, fig and that of the California black walnut are some of the most resistant among fruit-bearing trees and these may usually be planted with safety. The cherry is the most resistant of the stone fruits.

Fruit Drop.—The fruit falls to the ground while still very small and undeveloped, due partly to seasonal conditions which can not be controlled, and partly to a lack of cross pollination, which can be secured by mixing varieties in planting. Heavy rains at the time of blossoming may have this effect, and it may also be produced by frost, killing the young germ in the seed of the fruit. Many other fruits are affected in the same way, such as the apricot, cherry, peach, and pear. The fruit may remain on the tree and continue to grow in size for some time before dropping.

Sour Sap.—When affected with this trouble the tree may suddenly die just as it is coming out in the spring in full vigor, or the effect may be limited to one limb or one portion of the tree, which dies after the leaves have started, or even after the fruit is partly grown. All our stone fruits suffer frequently with the disease characterized by this name, while occasionally the pear and other trees are affected. The trouble appears to be due entirely to climatic conditions resulting from a combination of unseasonably warm, balmy weather in winter, followed by a marked change to colder weather. The sap of these trees frequently starts into active circulation with the first approach of spring, and when this occurs too early in the season, cold weather following suddenly, checks the flow of sap and other functional activities of the tree, causing a stagnation and finally fermentation. Affected trees should be pruned back to healthy wood, where there is enough remaining to make a new top.

Die-Back.—Numerous more or less abandoned groves of almonds, as well as other deciduous fruit trees, are to be seen in California which present a distressing appearance on account of a dying back of the branches. In some cases the trees are entirely dead, while in others they show all stages of deterioration. The trouble in the majority of these cases is due primarily to a lack of water induced by a variety of causes, either an absolute lack of sufficient moisture during the year to keep the trees alive, or unfavorable soil conditions, such as hardpan, gravel, and similar troubles. Lack of soil fertility is frequently a contributory factor. Such cases of die-back are connected usually with some of the unfavorable soil conditions which we have described in connection with that subject. In the majority of cases these plantings were doomed to failure from the start and represent an ill-advised undertaking, or in some cases criminal deception. Various secondary causes may contribute to the dying of such trees as we have described, but such factors are usually of little importance, and in many cases are an actual blessing to the owner in hastening the time when his expenditures for the maintenance of such an orchard are brought to an end.—(Cal. E. S. B. 218.)

Other Almond Diseases.—Yellows—(See page 482); Crown Gall—(See page 451).

DISEASES OF APRICOTS.

Shot-hole and Fruit Spot.—This fungus is the same as that causing the peach blight and produces in the apricot a spotting of the fruit, shot-hole effect in the leaves and killing of the buds. Spray with Bordeaux mixture during November and again in spring just as the buds open. (See Bulletin 203, page 33, California Experiment Station.)

Bud Blight.—Characterized by a dying of the buds during the early winter and caused very largely by the fungus just mentioned. Similar trouble is caused more or less by sour sap conditions.

Scab.—Causes a scabby spotting on the surface of the fruit. Has never been sufficiently serious to warrant treatment in California.

Brown Rot.—A decay of the fruit while still on the tree, occurring some seasons in the vicinity of San Francisco bay and other moist localities. The young growth as well as the fruit is also sometimes affected, the new shoots wilting and dying back from the attacks of this fungus. This is the most serious obstacle to stone fruit production in the eastern states, but does not find sufficient moisture for its development in California, except on early varieties in occasional seasons of late rains in the localities mentioned above. No definite remedy for this trouble has been demonstrated in California, but spraying with self-boiled lime sulphur just as the fruit is setting and again with the same following subsequent rains is recommended for trial.

Blossom Rot.—The young fruit decays while still very small and enclosed by the calyx or outer cup of the blossom. The trouble occurs when wet rainy weather prevails during the time of fruit setting. It commences in a rotting of the calyx cup, which is dead and susceptible to decay by saprophytic fungi, which decay spreads to the young fruit. It is caused by various fungi, of which perhaps a species of *Sclerotinia,* apparently *S. libertiana,* is most common, causing a decay of the young fruit on the tree. When such fruit is picked and placed in a moist chamber it develops an abundant cottony mold in which black sclerotia soon forms. This appears to be the same fungus causing the cottony mold or white rot of the lemon storage. *Botrytis vulgaris* is also common in this trouble. Same treatment as brown rot. Spraying for shot-hole fungus might also be of some benefit in this trouble.

Sour Sap and Seasonal Effects.—The apricot is particularly sensitive to sour sap (see Almond) and other seasonal effects. It is a tree having a free flow of sap, quick to respond to stimulating influences and one having the characteristic of all the stone fruits of forming an abundance of gum when injured in any manner. On this account, if any active sap movement from the roots is started early in the season by warm weather or an abundance of moisture and this activity be checked again by less stimulating weather conditions, trouble is very apt to follow. The sap becomes stagnant in the tissues, full of sugars and other easily fermentable substances, gum begins to form, sun burn may also occur and very often severe injury take place in the tissues of the sap wood and cambium layer.—(Cal. E. S. B. 218.)

Other Apricot Diseases.—Yellows—(See page 482); Blight—(See page 464).

PLUM DISEASES.

Black Knot.—The black knot is a rough wart-like outgrowth from the bark of twigs and branches in severe cases extending along the trunk for several feet. The first symptom is the swelling of the tissue just beneath the bark. This enlargement increases during the fall or growing season until the bark is ruptured. This exposed portion of the twig is soon covered with an olive green velvety coating composed of the reproductive hyphae of the fungus. A microscopical examination of the diseased portion at this time would show numerous erect hyphae bearing spores—the so-called summer spores. These are readily carried about by the wind and other agencies and serve to spread the disease during the growing season. Later in the season the production of summer spores ceases and the velvety covering gradually disappears. The surface of the wart gradually becomes hardened and altered in color to a dark brown and finally to a dead black. Pimples may be seen late in the fall covering the wart. In these are developed the winter spores called ascospores. These ascospores only develop during the winter and are capable of germination in February and March.—(Ala. E. S. B. 132.)

The diseased twigs should be removed after leaf-fall or before the winter spores are formed. Twigs that show in the spring or early summer the beginning of a "knot" should be removed and burned to prevent the formation of the summer spores.

Bacterial Black Spot.—This trouble, apparently, occurs only on the Japanese plums, but may attack any of the varieties of these, according to growers. The green plums show conspicuous black-purple spots which are often slightly sunken. These spots vary in size up to half an inch in diameter. There are not many on a single plum and these are usually isolated. The diseased tissue does not extend much below the skin, so the injury is quite superficial. Usually only a few plums scattered over the tree show the trouble, but occurring on the green fruit one is apt to fear that later it will develop into a very serious pest. This does not happen, as the trouble becomes less conspicuous and vigorous on the ripening fruit and fails to spread further. Specimens of the nearly grown but green fruit when placed in a moist chamber in the laboratory did not show any further progress of the disease though kept for some time under observation. Cultures made from diseased tissue from the interior uniformly gave growths of a yellow motile organism, thus showing bacteria to be the cause. Dr. E. F. Smith states that the disease also occurs on the leaves forming numerous small water-soaked spots which finally may end in shot holes.—(Conn. E. S. Report, 1905.)

While the disease in its present condition is not very serious, one can not assume that it will remain so since it may spread to other varieties and become more virulent. Though of bacterial origin, it is quite different from the bacterial blight that has been found occasionally on the plum and commonly on the pear, etc.

Plum Pockets.—This disease on account of its very characteristic and striking symptoms has long been known to horticulturists and others. It is very widely distributed throughout the United States. The vegetative portion or mycelium lives over winter in the younger twigs and grows out into the developing ovaries in the spring. All or most all of the parts of the ovary are affected and the action of the fungus is to greatly stimulate the tissues of the ovary so that a very rapid growth takes place. The result is a much swollen, somewhat irregular and spongy body of light yellowish or white color. No stone is developed in this plum-pocket but the center is hollow or frequently traversed by loose threads of torn tissue.

The leaf buds and young twigs may also become modified by the action of this fungus to form very irregular spongy swollen objects. In this case the resulting hypertrophy varies with the stage at which the fungus begins its work. If the leaves are not far developed when attacked their normal form may never be attained, but the hypertrophy may affect only a portion of the leaf if its attack is made upon the leaf when partly grown.

This disease is produced by the fungus *Exoascus pruni*—a species somewhat closely related to the one causing the leaf curl of the peach. No special spraying treatment can be recommended, though the use of Bordeaux mixture would no doubt reduce the chance of infection. Diseased fruits, buds, leaves and twigs should be removed and burned.—(Ala. E. S. B. 132.)

Plum Rot.—This is by all odds the most serious disease with which Ohio plum growers have to deal, outranking by far blackknot, shot-hole fungus and all the other ills plums are heir to. It is the same in character as the rot of other stone fruits. As with the peach, the rot fungus* lives over winter in the mummy rotted plums of the year before and possibly, to a limited extent, in affected branches. The first step in successful control of rot is the removal and burning of these old plums. The next step is to spray thoroughly. Likewise, control the curculio. No halfway measures will yield satisfactory results in dealing with plum rot. (Treatment—Same as for brown rot of peach.)

Shot-Hole Fungus.—This is at times a very destructive disease of the plum. It is due to the same fungus† which attacks the cherry, although in this case even more serious injury is liable to result than with cherry trees. Where trees are defoliated by shot-

**Monilia fructigena* Pers.
†*Cylindrosporium Padi* Karst.

hole fungus the fruit is of small value and the trees put forth new foliage and blossoms, thus leaving immature wood and a sappy condition for trouble in winter. Under such circumstances the secondary losses may be enormous. This fungus is readily prevented by spraying with self-boiled lime sulfur, the first application being made when the leaves are half grown, and two more at intervals of about three weeks.—(Ohio E. S. B. 121.)

Other Plum Diseases.—Yellows—(See page 482); Crown Gall —(See page 451); Root Rots—(See page 452).

PEACH DISEASES.

The Peach Blight.—The fungus causing the so-called blight, or shot-hole fungus, has been identified by us as *Coryneum beyerinkii.* This has been mentioned frequently as doing damage in this country, though never to nearly so great an extent as in California. The trouble consists in the dying of the buds on the fruiting wood, spotting of the green twigs, and dropping or non-development of the young leaves and fruit. Particularly noticeable, and the most prominent feature of the disease, was a copious gumming, or exudation of masses of gelatinous sap from the twigs, originating in the dead spots and buds. This gumming was extremely abundant in wet weather all over the one-year-old fruiting twigs of affected trees, and with the blighted leaves and fruit and spotted, leafless, dead or dying twigs and shoots, gave the tree a most distressing and alarming appearance. The crop was entirely ruined in badly affected orchards and the trees brought into an extremely weakened condition.

This describes, in a general way, the nature of this disease. It is readily distinguished from any other peach trouble by the features mentioned. It is essentially a winter or early spring disease of the fruiting twigs, the one-year-old wood which is the valuable part of the tree. This growth becomes killed all through the tree, except in the very top, and very serious loss and injury result. Most of the infection takes place in the winter, before the new growth starts, on twigs which were healthy and free from the trouble at the end of the growing season the previous fall. The new fruit becomes affected to some extent, but the principal damage is done by the killing of the buds and whole twigs at a period previous to the development of fruit.

Spraying in the latter part of October seemed effective, and from then on to the middle or last of December the best results of one application were secured in preventing blight infection. The attacks of curl leaf complicated matters. In many cases a complete blight control, obtained by early spraying, was nullified by unchecked attacks of the other disease. Spraying in November and December did not altogether hold the curl in check, while the February and March applications did so perfectly. It therefore seems best in the future to advise *two sprayings, one early and one late,* to insure freedom from both diseases.

Practically all these results refer to Bordeaux mixture. We have reason to feel sure that lime, salt, and sulfur spray would give equally as good results, but for the blight alone the more easily prepared Bordeaux is usually preferable. We have not laid great stress on the exact formula for the Bordeaux mixture to be used. Where the mixture was properly prepared very little difference in the results has appeared, whether it was 20-20-200, 30-35-200, or very much stronger as some have used it. Ordinarily the 20-20-200 formula is probably strong enough and affords some saving of material over a heavier application. A mixture containing more copper and lime remains longer on the tree, however, is not as quickly washed off by rain, and shows more plainly on the tree just how thoroughly it has been covered. We would therefore advise the use of the lesser strength only when materials are very high and scarce or where the workmen are particularly adept in applying the spray perfectly. For average conditions we prefer the 30-35-200 for the early application.—(Cal. E. S. B. 191.)

Brown-Rot.—This is a fungous disease which affects the stone fruits, such as the peach, plum, and cherry, and to a less extent some of the pome fruits, such as the apple, pear, and quince, producing a so-called rot of the fruit and blight of the twigs. It is caused by a fungus known to botanists as *Sclerotinia fructigena.* Brown-rot is the common name usually applied to the disease, but monilia, the generic name of the imperfect stage of the fungus, is often used by some of the older fruit growers.

The disease appears on the fruit as a small circular brown spot, which under moist, warm conditions enlarges rapidly, soon involving the entire fruit in decay. The spots do not usually become shrunken, and the fruit remains plump until almost entirely decayed. The fungus growing in the tissues of the fruit breaks through the skin, forming small, grayish tufts of spore-bearing threads. These tufts, although few on young spots, soon become so numerous as to give the diseased area a grayish, moldy appearance, which is responsible for the term peach mold sometimes applied to the disease. The spores which are produced in great abundance by these fungous tufts are blown by the wind and carried by insects and birds from fruit to fruit, tree to tree, and orchard to orchard. Finding lodgment on the fruit under favorable conditions of temperature and moisture, these spores germinate, producing a fungous growth, which ramifies and kills the tissues. These dead tissues turn brown, and the fungus breaks through the surface, producing another crop of spores. The process is very rapid, only a few days intervening between one generation of spores and another.

Although the young fruits soon after the petals are shed may become affected, as a rule no marked outbreak occurs until the fruit is half grown or larger, and the greatest destruction is wrought at harvest time. The fruit crop may reach maturity in perfect condition and yet be destroyed before it can be picked. Moreover, the fruit may become affected in transit or after reaching the market. It is no uncommon experience among peach growers to have a carload of peaches leave the orchard in apparently good condition and arrive on the market specked and practically worthless, owing to the brown-rot fungus. Through handling by pickers and packers some fruit in every package may become contaminated with spores from a few diseased fruits in the orchard. Enough moisture usually develops in the car to germinate the spores, and if the refrigeration is poor the fruit is likely to go down in partial or total decay before reaching the consumer.

The fungus also attacks the blossoms and extends from these into the fruit-bearing twigs, often girdling them. In a wet spring the fruit crop may thus be materially reduced, although this form of attack is only occasionally serious. In like manner the fungus may extend from diseased fruits into the twigs. Following an outbreak of brown-rot on the fruit, these twig infections may become so severe as to give the trees a blighted appearance.

The affected fruits largely drop to the ground, although many of them hang on the trees for months. They become dried and shriveled, and at this stage are known as brown-rot mummies. The fungus passes the winter in these mummies, which form the chief source of infection for the new fruit crop. When moistened by spring rains, the mummified fruits on the trees and on the ground become covered with fruiting tufts of the fungus, producing countless numbers of spores.

After 18 months, or at the end of the second winter, about the time peach trees are in bloom, there arises from the mummies on the ground, partly or entirely covered with soil, fruiting bodies representing the perfect stage of the fungus. These are dark-brown somewhat bell-shaped disks, resembling toadstools. In them are produced an abundance of ascospores, which rise in the air and are wafted by the wind. These, as well as the summer spores (conidia), serve to infect the blossoms and young fruits. The propagation of the fungus being thus so abundantly provided for, it is not surprising that a crop of fruit may be destroyed without much warning.

In sections where the brown-rot is prevalent the spores are practically omnipresent, and only favorable conditions for their germination and the rapid growth of the fungus are required to start an outbreak of the disease. The most important factor is excessive moisture in the form of rain, which not only favors the production and germination of the spores and the growth of the fungus, but renders the fruit soft and watery, and therefore more susceptible to the disease. High temperatures also favor the disease, although the fungus grows readily in mild summer temperatures. Prolonged cloudy weather with frequent light showers is more dangerous than a hard rain followed by clearing. Warm, muggy weather, when the fruit is maturing, is often disastrous to the crop.

Insects, especially the curculio and certain plant bugs, play an important part in the distribution of the spores and the infection of the fruit. Although the fungus under favorable conditions is apparently able to pass readily through the unbroken skin of the fruit, it is greatly aided by insect abrasions. In the process of feeding and egg laying, the curculio punctures the skin of the fruit, opening the way for the fungus and in many cases perhaps actually inserting the spores. This insect may render spraying for brown-rot partially ineffective by breaking the sprayed skin of the fruit, thus exposing the flesh to attack. In the treatment of the disease it is, therefore, important to combine an insecticide with the fungicide so as to destroy the beetles.

Experiments conducted by the Bureau of Plant Industry during the past four years have shown conclusively that this disease can be controlled by the use of self-boiled lime-sulphur mixture.—(F. B. 440.)

Peach Scab.—Of the diseases affecting the fruit of the peach, scab is second only to brown-rot in economic importance; in fact, it is more destructive than brown-rot in some of the mountain districts. It dwarfs the fruit and causes premature dropping, thereby reducing the yield; it ruptures the skin, opening the way for brown-rot attacks; and it mars the appearance of the fruit, thus lowering the grade and reducing its market value. The disease is common wherever peaches are grown east of the Rocky Mountains, scarcely an orchard being entirely free from it. In some cases, especially in a dry season, only a small percentage of the fruit may become affected and with only a few small harmless spots, while in other cases the entire crop may become so badly affected as to be unmarketable. If the loss in the orchard and the reduction in market value are both considered, it seems evident that a loss of 10 per cent of the total value of the peach crop in the eastern United States is caused by peach scab.

The name commonly applied to this disease is "peach scab," but it is also known as black spot and freckles and in some districts it is often improperly called mildew. It is caused by the fungus *Cladosporium carpophilum* Thum., which grows in the skin of the fruit, producing small, circular dark-brown spots. When numerous, these spots give the fruit a smutty or blackened appearance and cause the skin to crack. Fruit badly affected does not reach normal size and often drops prematurely.

The fungus also attacks the twigs, producing brown spots, in which it passes the winter. These spots are very common in peach orchards, but they apparently do little damage to the twigs. During the spring or early summer the fungus growing in the spots produces olive-brown spores which serve to infect the young peaches. Similar spores are also produced on the fruit spots.—(F. B. 440.)

There is a considerable difference in varieties as to their susceptibility to peach scab. In general, the late varieties are much more susceptible than the early varieties. This is due, in part at least, to the fact that the fruit of the late-maturing varieties is exposed to infection over a longer period and the opportunity for the development of the disease is greater. Of the commercial varieties, the Heath is perhaps the most susceptible; in fact, the disease has almost prohibited the growing of this variety except in a small way. The Bilyeu variety is also badly affected and the disease has restricted its culture to high, well-drained locations. The Salway, Smock, and most of the other varieties that ripen after the Elberta usually suffer rather severely from this disease, while the Elberta may be considered somewhat less affected, although the crop of this variety often becomes badly diseased. The varieties that ripen earlier than Elberta are as a rule only slightly or moderately affected. This is especially true of the Carman, Hiley, Champion, and Belle. On the other hand, the Mountain Rose and Early Rivers are quite susceptible to the disease.

The development of the self-boiled lime-sulphur mixture as a fungicide has made possible the control of the scab without injury to the fruit or foliage. The injury produced by this disease may be almost entirely prevented at a small cost. This has been abundantly demonstrated through experiments conducted by the Bureau of Plant Industry during the past three or four years.—(F. B. 440.)

Most of the peach orchards in the eastern half of the United States should be given the combined treatment for brown-rot, scab, and curculio. This is particularly true of the southern orchards, where all these troubles are prevalent. In some of the more northern orchards the curculio is not very troublesome, but as a rule it will probably pay to add the arsenate of lead in at least the first lime-sulphur application.

The self-boiled lime-sulphur mixture referred to in the following outlines of treatment should be made of a strength of 8 pounds of lime and 8 pounds of sulphur to each 50 gallons of water, and the arsenate of lead should be used at the rate of 2 pounds to each 50 gallons of the mixture or of water. When the poison is used in water there should be added the milk of lime made from slaking 2 to 3 pounds of good stone lime. When used in the lime-sulphur mixture additional lime will not be necessary.—(F. B. 440.)

Midseason Varieties.—The midseason varieties of peaches, such as Reeves, Belle, Early Crawford, Elberta, Late Crawford, Chairs, Fox, and Beers Smock, should be sprayed as follows:

(1) With arsenate of lead alone, about 10 days after the petals fall, or at the time the calyxes are shedding.

(2) With self-boiled lime-sulphur and arsenate of lead, two weeks later, or four to five weeks after the petals have been shed.

(3) With self-boiled lime-sulphur alone, four to five weeks before the fruit ripens.

Late Varieties.—The Salway, Heath, Bilyeu, and varieties with a similar ripening period should be given the same treatment prescribed for midseason varieties, with an additional treatment of self-boiled lime-sulphur alone, to be applied three or four weeks after the second application.

Early Varieties.—The Greensboro, Carman, Hiley, Mountain Rose, and varieties having the same ripening period should receive the first and second applications prescribed for midseason varieties. Where the curculio is not particularly bad, as in Connecticut, western New York, and Michigan, the first treatment, which is for this insect only, may be omitted. Also for numerous orchards throughout the Middle States where the insect, especially in the younger orchards, is not yet very troublesome, orchardists should use their judgment as to whether the first application may be safely omitted. Where peach scab is the chief trouble, and brown-rot and curculio are of only minor importance, as may be the case in some of the Allegheny Mountain districts, satisfactory results may be had from two applications, namely, the first with self-boiled lime-sulphur and arsenate of lead four to five weeks after the petals fall, and the second treatment of the above schedule with self-boiled lime-sulphur alone three to four weeks later. These two treatments, if thoroughly applied, will control the scab and brown-rot, especially on the early and midseason varieties, and will materially reduce curculio injuries. Even one application of the combined spray made about five weeks after the petals fall would pay well, although this is recommended only for conditions where it is not feasible to do more. —(F. B. 440.)

Peach Leaf-Curl.—Peach leaves affected with the curl can often be detected as soon as the leaf buds have opened to a slight extent. A roughened surface of the young leaf and an excess of coloring are usually the first indications. As the young leaves rapidly assume their normal size, this curling and arching of the blades is more prominent. Sometimes there is distortion in a small area only, and again the entire blade may be affected. The curling of the edges of the leaves may be upward or downward, or the upper surface of the leaf may be gradually arched from base to tip. When the leaf is full grown, the diseased areas may be reddish green; but usually the green color is largely lost and a pale discoloration characterizes diseased parts. Not only are leaf and leaf-stalk affected, but the terminal part of the shoot becomes much enlarged, and also pale in color. The fungus is then thoroughly established in the tip of the branch, and the significance of this is apparent later on. The leaves soon become grayish or mealy in appearance. This appearance is due to the fact that the fungus is fruiting, producing the spores which are to disseminate the disease. After the grayish color appears, the affected leaves gradually dry up and fall off. In this latitude the defoliation from such injuries usually occurs late in June.

In the late stages of this curl disease, as with some other peach diseases, gummy exudations are often noted on those twigs which are enlarged by the fungus; or these may occur even on the large branches where a diseased cluster of leaves has been attached.

Defoliation of the entire tree does not necessarily mean the death of the tree, but it does mean the death of many twigs, and lessened vitality. New buds, or rather some of the sleeping or dormant buds open and the tree attempts to supply itself with new and healthy foliage. It is very seldom that this fresh foliage is badly affected by the curl; and it is possible to account for whatever curl is now evident as having come directly from diseased buds or twigs.

The new shoot growing out from a diseased terminal bud may grow entirely out of the disease, but the swollen part remains below. Thus, when the season's growth is done and the autumn at hand, these swollen areas may mark out the recovery of shoots; but they also indicate where the fungus rests; and they are warnings of danger for another season.—(N. Y. [Cornell] E. S. B. 164.)

Little Peach Disease.—Though the little peach disease has been much discussed in horticultural papers and elsewhere, its characteristics are so little understood by New York orchardists that other troubles are often mistaken for it. Knowing that the disease exists in the State, any general occurrence of small peaches in an orchard leads the owner to fear an outbreak of this dreaded disease.

But small peaches, even though they may occur quite generally throughout an orchard, and may destroy all chance of profit for the year, do not alone indicate little peach. They may be due to overbearing of the previous year, to unsuitable soil, to lack of available plant food, to unfavorable climatic conditions, and to other causes. The trees should not be destroyed until the owner knows surely that the trouble is little peach, for from these other conditions the chances of recovery are good. If convinced that the trouble is the true disease, however, no time should be lost in taking out the trees, for little peach ranks with yellows in destructiveness and apparent communicability. Trees affected with it never recover.

An orchard near Penn Yan, consisting of 150 ten-year-old trees of Globe peaches bore only one-sixth or one-eighth of a crop of full sized peaches last year, the remaining fruits of a full setting being too small for market. The owner thought the trouble little peach, but it was due to improper fertilization of the flowers at setting time.

The little, unfertilized or imperfectly fertilized fruits, instead of falling at the June drop hung on the trees until fall. Some of them made considerable growth, but on cutting open the smaller ones they were found to contain soft, imperfect pits with small or no kernels. This showed that they were not properly fertilized. Why they were not, or why they hung on in spite of lack of fertilization, could not be determined. The orchard seemed to be healthy, the trees had borne good loads the previous year, but not excessive ones as the fruits were thinned; soil and atmospheric conditions appeared favorable; and trees of other varieties in the same orchard were unaffected, except Elberta, which showed traces of the same disease.

In little peach all the fruits on the affected limb or side of the tree are small and of quite uniform size; in this trouble full-sized perfect fruits were found side by side with others varying from two-thirds normal size down to the size of a hickory nut. In little peach the pits are of full size with well developed kernels, even though the fruits are small, while in the imperfectly fertilized peaches the size of the pits varies with the size of the fruits.—(N. Y. [Geneva] E. S. B. 200.)

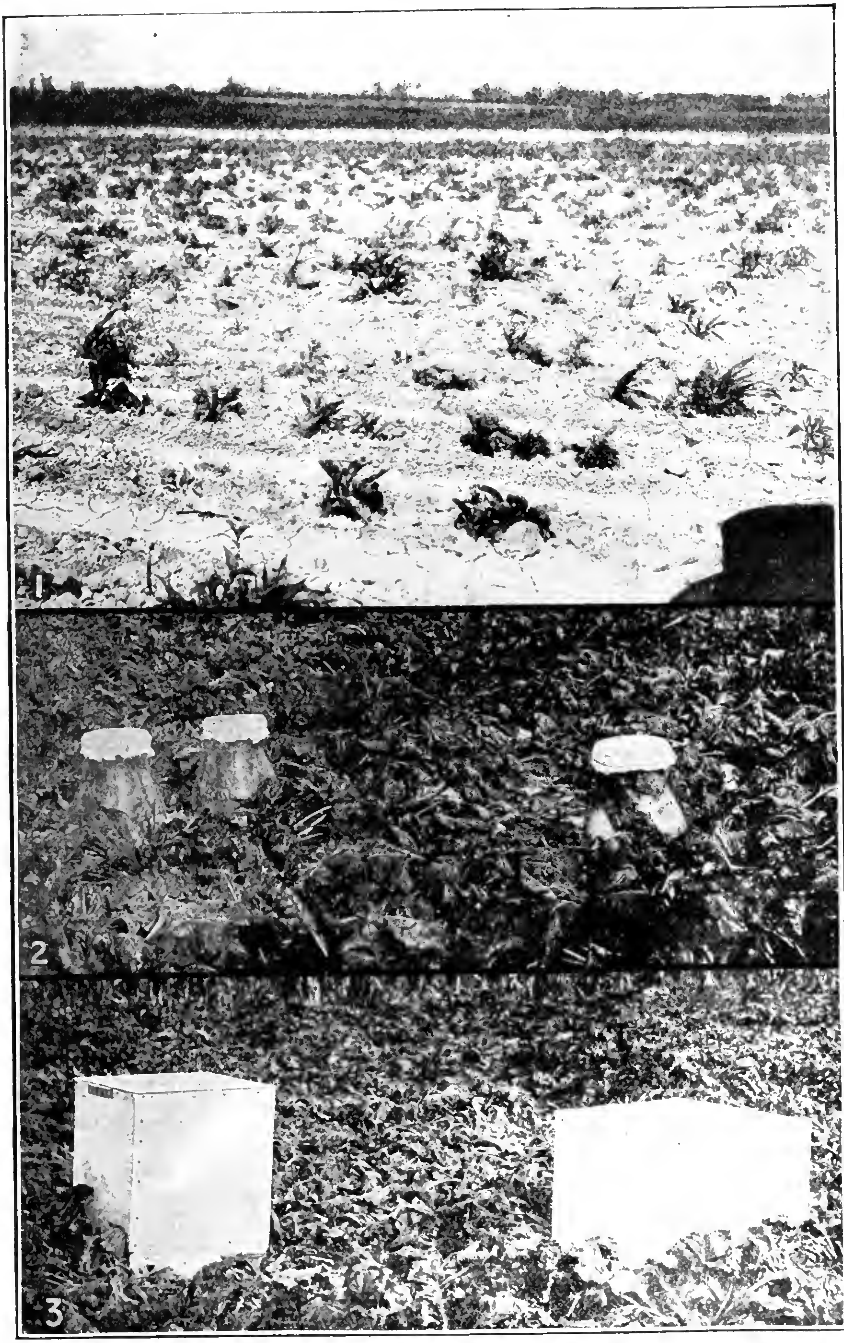
Peach Mildew.—The injury is due to a fungus which attacks leaves, twigs and fruit alike. It appears on the fruits while they are yet small and immature, often causing them to fall prematurely. Its first appearance is indicated by a musty or frost-like patch upon the surface. When well established, the spots become almost pure white; the color being due to the mycelium and its fruiting branches, which overrun the surface upon which the fungus establishes itself. The flesh of the fruit becomes hard under these spots and the skin takes on a brown or dead color. The appearance upon the twig is very much the same, it being very conspicuous as white blotches along the twigs; the underlying bark becoming dry and brown. Where the attack is very severe the leaves fall, the bark becomes shriveled, and the young tips often assume a curved position. It only appears on the current year's growth, it being able to establish itself upon the more tender growing parts only. On the leaves, it generally appears upon the under surface, most prominently along the midrib as white, irregular blotches. The attack is not confined to the under surface of the leaf, but is found there more often, probably because strong sunlight is its worst enemy. The leaves become crimpled and curled, the younger ones near the tip often falling during severe attacks. The tissues of the leaf are deadened, and it folds more or less along the midrib, the upper surface folding upon itself.

Attacks of this fungus often injure the fruit, in some cases almost ruining the crop for market. The young twigs are checked in their growth, and sometimes killed outright, while the foliage is greatly reduced. If no injury to the crop is experienced during the season of attack it is no doubt true that the future crops and good health of the tree are at stake. Fruit buds for the coming year cannot be developed on half-dead twigs poorly nourished by a scant supply of foliage. Neither is the tree in shape to withstand other troubles to which the unhealthy peach tree falls heir.—(Col. E. S. B. 107.)

Peach Rosette.—It commonly appears in the spring and may attack either a single branch or the entire tree. The leaves come out in clusters from nearly all the buds on the twigs and form compact whorls, consisting sometimes of several dozen, and which frequently measure from two to four inches in length. Not uncommonly these clusters of leaves come out in great numbers from the sides of the trunk or the main branches of the tree, places where, under normal condition, buds would never develop. At the base of the clusters there are generally a few large leaves which are brittle and the edges somewhat rolled, while at the tips the leaves are very small and tender. Usually the leaves fall in mid-summer or early autumn, leaving the trees nude. This peculiar whorled arrangement of the leaves makes the disease very easily recognized, and one who has seen an illustration of Rosette cannot fail to recognize the disease should he meet with it in his orchard.

Yellows and Rosette are in some respects very similar, and at the first appearance of the disease Rosette was probably considered as a variety of Yellows peculiar to the South, but they were later established as distinct and separate diseases; the chief differences between Yellows and Rosette being the generally much less tufted or rosetted condition of the leaves, the much more lingering nature of the Yellows, which usually lasts two or three or even four seasons.—(Mo. State Fruit E. S. B. 11).

Peach Yellows.—One of the most prominent symptoms of yellows is the premature ripening of the fruit. Affected trees may ripen all or only a portion of their fruit from a few days to several weeks



Work of Eutettix Tenella on Sugar Beets. 1. A Field of Beets Devastated by Curly-Leaf. 2 and 3. Cages Used in Life-History Experiments of the Insects. Dept. of Agr.

in advance of the normal season of ripening. The prematurely ripened fruit almost invariably has a characteristic appearance which a careful observer can detect. Instead of uniform masses and blending of color the fruit has a red spotted or blotched appearance; these red spots or blotches may be few or numerous and occur largely near the surface or through the flesh to the pit. The flesh surrounding the pit is also usually much more red than in normal fruit. In some instances affected trees produce fruit which is very highly colored and the red spotting is almost obscured. Specimen fruits will sometimes be found upon diseased trees which fail to show the characteristic red spotting although the flesh about the pit will usually indicate yellows. Sometimes only one branch of a tree will apparently be affected and while the fruit upon this affected branch is prematurely ripe the fruit upon the remainder of the tree will be entirely green.

The flavor and quality of the premature fruit is somewhat variable. When it ripens several weeks in advance of its normal season it is usually under normal size, watery fleshed, insipid and sometimes bitter. When the fruit ripens at about the normal time, however, it may be of fair quality. Such fruit usually occurs upon trees which have apparently been affected only for a short time.

Peach trees sometimes produce premature fruit because of girdling by borers or other injuries, but such cases can readily be determined from yellows. The premature fruit caused by yellows is very susceptible to the brown rot and decays rapidly under conditions favorable to that disease.

Another prominent symptom of yellows is the characteristic development of slender, wiry, yellowish-green shoots upon the trunk and lower branches of affected trees. The leaves upon these shoots are smaller and more narrow than upon healthy twigs besides having a starved, sickly, greenish-yellow appearance. The characteristic shoots sometimes develop at the tips of branches as well as upon the trunk and lower limbs. In some instances, only a few of these slender, wiry shoots are produced on each tree while in other cases they push out over the entire tree. Affected trees can often be detected in the dormant season by this wiry twig development. Occasionally these wiry twigs will make a late fall growth and retain leaves for a time after the other branches are dormant.

In advanced stages of yellows the premature red-spotted fruit and the weak, sickly appearing shoots are commonly found upon each tree, but in the earlier stages the red spotted premature fruit may appear first and in other cases the slender shoots. Trees affected with yellows commonly have a sickly, yellowish-green appearance, and the diseased trees in an orchard can be detected from a distance because of this. Closely observe the behavior of each tree in the orchard from the beginning. If symptoms of yellows or little peach appear in any tree, pull it out at once and destroy it by burning. Do not allow an affected tree to remain in the orchard from fall until spring.

Individual trees which grow very poorly in a young orchard are of doubtful value whether affected with yellows or not and had best be pulled out and replaced by others. In certain special cases where the poor growth is known to be caused by such factors as scale or borers it may be better economy to leave the tree if it can be properly cared for.—(N. J. E. S. B. 226.)

Gummosis of Peach.—Cases of gummosis in peach trees are not uncommon. Gum starts to flow from the trunk or larger branches during the early part of the summer and large drops are formed on the bark, often reaching an inch in diameter and nearly as round as marbles. The bark becomes broken down to such an extent that the tree is girdled and finally dies. Trees in the early stages can apparently be saved by a vertical slitting of the bark about the affected part. Make the cuts about two inches apart and as deep as possible with a sharp knife. The recovery of trees thus treated would seem to indicate that the trouble is due to a tightening, or binding, of the old bark.

Physiological Troubles.—Many yellow pear trees have come under observation during the season, and in most cases the trouble can be attributed to poor soil conditions, probably to excessive watering.

Copper Sulphate Injury.—Copper sulphate has been placed about trees with injurious results. When taken up by the roots in strong solutions it deadens the tissue through which it passes. Its use should be discouraged, as it has not been proven of any value in combating root diseases.

Arsenical Poisoning.—The stock solution used in preparing arsenite of lime, and made by dissolving white arsenic in water and sal soda, is very destructive to plant life. The practice of keeping this solution under a tree in the orchard should be abandoned. A very small amount spilled on the ground may mean the loss of the tree. The fumes given off by this material when being boiled is injurious to plant life and the boiling should be done at some distance from the orchard.—(Col. E. S. B. 43.)

Shot-Hole Fungus on Cherry Fruit-Pedicels.—In New York State the shot-hole fungus, *Cylindrosporium padi* Karst., does more or less damage every season. It is destructive to both plums and cherries in the nursery and in the orchard. Among cherries, the English Morello is especially susceptible to the disease. Trees of this variety often drop their leaves quite freely as early as June 26 and in some cases the trees are nearly defoliated by August 1.

On June 26 while examining some seriously affected English Morello trees at Milton it was observed that many of the fruit-pedicels bore brown spots of considerable size. Upon microscopic examination it was found that the spots were caused by the shot-hole fungus, *Cylindrosporium padi.*

On July 11 the same thing was observed at Highland. In this case there was a long row of English Morello trees all heavily loaded with fruit. So many leaves had fallen that the trees looked bare. The fruit-pedicels were so generally attacked by the fungus that it was somewhat difficult to find one which was entirely free from the brown spots. The spots were from one-eighth to one-fourth inch in length and extended one-third to one-half the distance around the pedicel. In many cases they completely encircled the pedicel. Often the spots coalesced, and then a large portion, or even all, of the pedicel was brown. Even with the unaided eye, one could detect a white speck or, more often, a white rift, at the center of each spot. With the aid of a hand lens it could be plainly seen that the white specks were gelatinous spore masses. The affected pedicels almost invariably showed an abundance of the spores. The same was true at Milton two weeks earlier and also at Geneva, on July 13. There was no difficulty whatever in finding the spores.

The presence of the spots on the pedicels caused the fruit to ripen unevenly. Many of the fruits were dwarfed and some of those most severely attacked withered. However, these injuries can not, with justice, be attributed wholly to the spots on the pedicels. The premature falling of the leaves, also, had something to do with it.

We believe this to be the first record of the occurrence of *Cylindrosporium padi* on the fruit-pedicels of cherry. We do not say positively that such is the case, because we have not made an exhaustive examination of the literature; but it is at least safe to say that the fact is not generally known, because it is not mentioned in any of the many accounts examined by us.

In connection with the appearance of *Cylindrospœium* on the fruit-pedicels we have observed a spotting of the green fruits which gave cherry growers in the vicinty of Geneva considerable concern last spring. It was first brought to our attention by the Station Horticulturist, Mr. Beach, about June 15. The fruits, which were at that time about the size of peas, showed numerous small, brown, slightly sunken spots. As the fruits grew many of them became somewhat misshapen, seemingly as a consequence of the presence of the spots. The spots enlarged but little and there was no tendency to rot.

In the vicinity of Geneva this trouble was exceedingly common on English Morello and Montmorency Ordinaire and fruit growers were fearful that the crop would be injured; but as the cherries began to swell and color in ripening the spots seemed to disappear so there was little or no loss from it.

The cause of this spotting is unknown to us. Because of its constant association with *Cylindrosporium padi* on English Morello at Geneva, Milton and Highland it was at first suspected that it might be due to that fungus. However, no evidence of the presence of any fungus could be found on the spots. Moreover Montmorency Ordinaire, which was little affected by *Cylindrosporium* on the foliage, had nearly if not quite as much of the fruit spot as had English Morello. These two facts, particularly the latter, are opposed to the theory that the spots were due to *Cylindrosporium padi*.—(N. Y. [Geneva] E. S. B. 200.) [For other diseases see Peach and Plum.]

DISEASES OF SMALL FRUITS.

Anthracnose of Berries—Nature and Cause.—This disease which is commonly known by the popular name of anthracnose, is caused by a very small form of fungus (*Gloeosporium venetum*). consisting of two parts—the mycelium and the spores. The way in which the fungus passes the winter is not known. It probably lives in the canes and fragments of leaves that remain in the field after pruning is done. From field observation on the blackberry, the disease attacks the stems, leaves and fruit during the spring. The spread of the disease is caused by the distribution of the spores. Some of the spores lodge on the host plants. When the climatic conditions are favorable, the spores germinate and form the mycelium, which penetrates the tissue of the stems, leaves and fruit, causing spots on them. The mycelium soon gives rise to a large number of short branches just beneath the thin outer coat (epidermis). Spores are borne on these branches. When they form, they cause the epidermis to break open. These spores are held together by a mucilaginous substance which is soluble in water. In the presence of moisture, the spores are set free and are carried about by the wind and other agents. Some of them are sure to lodge on the various parts of the host plant.

The spots in the stems of plants affected are found to be elliptical in shape and have somewhat irregular margins. They vary in size from less to three or four times larger than a pin head —usually about twice as large. The center is a light grey to nearly white in color, while the margin is a deep brown. When these spots are mature in size they are sunken, and oftentimes split open lengthwise with the cane. They usually extend nearly through the bark. When abundant, irregular patches of considerable depth are formed, which act as a partial girdle on the stem.

The spots in the leaves are round and smaller than those in the canes—usually about half as large as the head of a pin. The centers are nearly white in color, while the borders are wider and of a reddish-brown color. These spots usually extend through the leaf, and when they are abundant run together, forming large patches. These dead areas drop out, leaving holes or slits in the leaves, causing them to appear as if whipped by the wind. The injury done the stem and leaves is very little as compared with the injury done the fruit.

When young drupels become infested, a small brown dot appears on the surface on the end. These areas increase rapidly in size and soon involve the entire surface. In the meantime, the infested portion stops growing, the surface becomes rough and marked with nearly white lines, caused by the epidermis splitting open. As the fruit matures and the amount of water increases in them, the infested areas become more or less shrunken. The spot becomes deeper brown in color. The center of each may become white, owing to the development of masses of spores. At this stage the fruit is nearly red in color, and the spots are very conspicuous.

Infested drupels on a well-matured fruit are of a dull reddish brown color. As the drupels mature, the proportion of water in the berry increases very greatly. If infection has taken place early in the season while the drupels are small and do not contain much water, they will remain firm and finally become dry. In case infection takes place when the drupels contain a considerable amount of water, however, they will crush very easily. Fortunately late infection is rather rare, as far as our observations go. A greater number of drupels on ripe fruit are dry enough so that they do not injure the shipping quality of the fruit. When the drupels become infested, the growth is only partially arrested. They continue to grow at the base and partially mature, but do not form a salable berry.

Kinds of Plants Attacked.—Among the varieties of blackberries, the Snyder, Kittatany and the Himalaya Giant are attacked. The Lucretia dewberry is also susceptible, while the Logan berry is by no means free from the disease. Of the red raspberries, the Antwerp is injured to a considerable degree, while the Cuthbert is but slightly affected. The Cumberland black raspberry and the Antwerp are equally affected.

Conclusion and Recommendations.

1. Anthracnose is caused by a small form of fungus.
2. Distribution of the fungus is accomplished by the spores.
3. Anthracnose attacks the Snyder, Kittatany and Himalaya Giant blackberries; the Lucretia dewberry, Logan berry; Antwerp and Cuthbert red raspberries, and the Cumberland black raspberry.
4. The disease is very injurious to the Snyder and Kittatany blackberries, attacking the stems, leaves and fruit.
5. A microscopic study and inoculation experiments show that the same fungus occurs in the spots on stems, leaves and fruit.
6. The fungus attacks the current year's growth of shoots, when they are six inches to one foot in height and later. Spots do not occur on the bases of these shoots.
7. The disease does not spread on the stems and its leaves after the branches form, since the canes and its leaves are infested, while the laterals and their leaves are usually free from the disease.
8. On the Snyder and Kittatany blackberries the fungus spreads from the stems and leaves to the fruit as soon as the young fruit forms.
9. The disease continues to spread on the fruit during the entire season. The fruit is damaged more or less severely, depending on date of infection and the number of drupels on each berry that becomes diseased.
10. The fungus probably lives over winter in the berry field in the leaves on the ground and in the canes.—(Wash. E. S. B. 97.)

Red Rust or Bramble Rust.—This is a well known disease of the wild and cultivated blackberries, which also attacks raspberries.

It causes the affected leaves to turn first yellowish in color, remain erect in position, and finally to become bright red with an abundant coating of the spores of the rust fungus. These spores are readily scattered and may thus affect previously healthy plants. The threads of the rust fungus (mycelium) live year after year in the affected plants. For this reason the only remedy is to dig and and burn all members of the rusted stools.—(Ohio E. S. B. 121 and 79.)

Crown Gall—(See page 451). Leaf Spot—(See page 491). Cane Blight—(See page 491).

Double Blossom of Dewberry.—The disease appears in the earily spring and can be readily recognized when the leaf buds open. The diseased buds are usually larger than the normal buds, and frequently accompanied by one or more small buds which are placed laterally to the main bud. When these diseased buds open, a witches' broom is produced instead of the normal shoots. The witches' broom may consist of a great mass of short, slender twigs, or there may be one good but somewhat reduced shoot, together with few to several of the short deformed shoots. The shoots of these witches' brooms will frequently remain green after the old canes are dead. The blossoms are usually deformed in varying degrees; having enlarged thickened sepals and petals, and sometimes an increase in number of each, especially the latter. The deformed petals are usually more or less wrinkled, giving the appearance of being doubled. The stamens and ovaries are also subject to slight modifications varying in degree and character with the severity of the disease.

The disease usually appears during the second year's harvest and increases from season to season until the plants are worthless. The disease does not vary in abundance from season to season except to increase with each succeeding year until it becomes necessary to destroy the plants. Very frequently old plants will have every bud deformed. Diseased plants also show a tendency to produce an abundance of late bloom which are usually smaller than the normal blossoms but not otherwise modified. They frequently bear the fungus and produce spores.—(Del. E. S. B. 93.)

However, the fact that the fungus does not penetrate beyond the base of the bud makes it possible to control the disease by hand picking of the diseased buds. This method has been tried and found to be efficient and also much cheaper than any spraying that is likely to be devised. The diseased parts should be picked off as soon as the leaf buds open, when they can be readily detected and easily removed. If the picking is delayed the growing foliage will partially conceal many diseased buds and make the work more difficult, require a longer time, and be less satisfactory. It is practically impossible to remove all diseased buds some of which may be only slightly affected and very small, but the removal of each diseased bud means the removal of a source of infection from which hundreds and even thousands of spores may be distributed to the surrounding plants. If the picking is done at the proper time, one person can examine and pick from 300 to 400 plants per hour. After this, diseased buds which are overlooked may be removed while cultivating the plants. It is very doubtful if the fungus will mature on these buds after removal, but as a precaution they should be destroyed.—(Del. E. S. B. 93.)

GOOSEBERRY.

Leaf-Spot.—The gooseberry leaves are attacked by the same leaf-spot fungus recorded upon the currant (*Septoria ribis* Desm.), although the defoliation may be even more severe than on the currant. In spraying experiments at this Station, conducted by the Horticulturist, it has been found that the gooseberry leaf-spot is more easily prevented than the currant leaf-spot. Indeed no fungus disease upon which we have experimented is more easily prevented when the fungicide is applied at the proper time. (See Spray Calendar). Often the leaves from gooseberry plants have all dropped before maturity of fruit, and in hot weather all the fruit has been lost on the unsprayed, check plants, while the sprayed plants gave a fine yield of satisfactory fruit.

Powdery Mildew.—This is a destructive fungus disease especially common upon English varieties such as Industry, Crown Bob, etc., it has been destructive also upon the Houghton. As already stated this mildew attacks currants. From the nature of this fungus the first spraying with Bordeaux mixture should be made early in the season. (See Bulletin 79). Subsequent applications may be either of Bordeaux mixture or potassium sulfid. After fruit is half grown the latter fungicide is to be preferred since it is more easily removed from the fruit.—(Ohio E. S. B. 214.)

Raspberry Cane Blight.—Both red and black raspberries are attacked, but on red varieties the symptoms are somewhat different from those on black ones. The principal damage is done to fruiting canes although new canes are attacked and occasionally killed during the first season of their growth. The foliage on affected canes wilts suddenly and becomes dry. The whole cane may be involved or only a portion of it. Often a single branch is killed while the remainder of the cane continues alive and apparently normal. In the majority of cases only a part of the cane dies. With black caps the disease frequently starts in the old stub left in pruning. From this point it gradually works downward killing first the uppermost branch, then the next lower one and so on until by the close of the berry harvest one-half or more of the cane may be dead. On black caps, the disease also shows a tendency to work down one side of the cane killing the bark and discoloring the wood on that side while on the other side the bark remains green. This may occasionally happen with the red varieties, but as a rule they are attacked at some particular point on the cane. Here the bark is dead and the wood brown. For some time the injury extends only part way around the cane and as long as there is a strip of green bark left connecting the parts above the point of attack with those below all goes well; but when the injury at length completely encircles the cane the leaves on the portion above the injury suddenly wilt and die. By the time this happens, the cane at the point of attack is dead throughout a section which is usually from two to four inches in length. Both above and below this dead section of the cane itself may be normal, with nothing to indicate the cause of the sudden wilting of the leaves. However, a cane may bear several of these dead sections of various sizes. If the point of attack is near the ground the whole cane dies; if higher up, only a part of it. When part of a cane dies while the remainder continues alive, the point of attack is to be sought at the boundary between the dead and living portions. Usually, the seat of the difficulty may be located by the color of the bark, which is somewhat different from that on the rest of the cane. For the most part it is lighter colored and smutty, with smoke-colored patches of exuded spores. In many cases numerous minute pimples, the pycnidia of the fungus, are visible. By cutting into the cane with a knife the matter may be decided at once. Where the cane is diseased the wood is strongly discolored. A marked characteristic of cane blight is the brittleness of the cane at the point of attack.

While it is common, both with black caps and red varieties, for the disease to be confined to one or more definite areas of infection on the cane there are also many instances in which the disease pervades a large portion of the cane before death occurs. In such cases it is common for the affected wood to crack and the bark to peel off, particularly on the lower portion of the cane.

Fruiting canes affected with cane blight may die at any time. Almost as soon as the leaves unfold in the spring branches commence to die. As the season advances the disease increases in virulence and reaches the maximum during the ripening of the fruit. Canes loaded with ripening fruit suddenly wilt, either wholly or in part, and dry up. The disease does not spread from an initial center, but canes die here and there all through the plantation. Thrifty, well-cared-for plantations suffer as well as neglected ones.

So far as observed, only the canes are affected. The disease certainly does not attack the leaves, and the fact that new canes in badly diseased plantations make as good a growth as those in healthy plantations, indicates that the roots are not affected.

In August and September the new canes of red raspberries often show bluish-black or brown areas from two to four inches in length and extending nearly or quite around the cane. These discolored areas are very conspicuous and at one time were mistaken for the early stage of cane blight. Probably they have nothing to do with cane blight.—(N. Y. [Geneva] E. S. B. 226.)

Raspberry Yellows.—The Marlboro red raspberry, a once popular variety, is said by fruit growers to be running out. In Ulster County particularly its culture is said to be no longer profitable; and throughout the Hudson Valley one frequently hears of the ravages of the Marlboro disease. The foliage and fruit dry up—sometimes gradually, sometimes suddenly. There has been much speculation concerning the cause of the trouble.

According to our observations the so-called Marlboro disease is, in reality, two diseases. It is partly cane blight (to which the variety is much subject) and partly another disease for which we propose the name Yellows. Plants attacked by yellows have a stunted, yellowish aspect suggestive of peach yellows and Woods' Bermuda lily disease, especially the latter. On fruiting canes the fruit-bearing laterals are dwarfed, often to one-half their normal length. The leaves are small, curled slightly downward at the margins and faintly mottled with yellow. Some of the berries dry up without ripening and those that ripen are undersized and insipid. Much of the foliage withers at the same time. New canes, for the most part, are not seriously checked in growth although their foliage is usually more or less affected. The foliage on new canes does not wither and there are rarely to be found any dead spots or areas. The leaves on the upper portion of the cane may be much mottled while those on the lower portion are nearly or quite normal. The reverse may also happen. Badly diseased canes and apparently healthy ones may be occasionally found in the same stool. However, it is often difficult to determine whether a particular cane is or is not diseased because the transition from normal canes to badly diseased ones is by imperceptible gradations. Except in the later stages of the disease and when also attacked by cane blight, the canes themselves do not show injury. The roots, too, appear normal but more observations must be made before it can be stated positively that the roots are entirely unaffected. Cause: Unknown. Treatment: None.—(N. Y. [Geneva] E. S. B. 226.)

STRAWBERRY DISEASES.

Aborted Fruits.—These mishappen fruits are rarely the result of disease, more often they are the indirect result of imperfect pollination. The effects of weather conditions in hindering pollination and making it imperfect are well known. Some bright sunny weather is all essential.

Anthracnose.—This has been found upon strawberry leaves in other states; it has given less trouble than the other foliage diseases with us up to this time.

Leaf-Spot or Rust.—This so-called is the most serious disease of older strawberry leaves. The leaf-spot fungus *(Sphaerella fragaria)* matures in the old leaves. In the earlier spots on young leaves three forms of fungi are found, most of which are probably stages in the development of the leaf-spot fungus. This disease is essentially one of the season before the crop is injured. Spraying upon new plantations after picking any fruit present will usually be found profitable. The practice of burning over strawberry beds after picking to destroy old leaves and the fungi upon them, as well as possible insects, is based upon right principles and is commonly successful.

FUNGOUS DISEASES OF THE CRANBERRY.

Only four of the diseases thus far found attacking the cranberry cause sufficient injury to need consideration here. These are what are popularly called, among growers, cranberry blast, cranberry scald, the cranberry rot, and anthracnose. Cranberry blast and scald are really but different effects produced by the same parasitic fungus.

Cranberry Blast.—Cranberry blast is a name given to that form of the disease which attacks the very young fruits as soon as the blossoms fall. It causes the fruit to shrivel up, become black, and finally become covered with one of the spore-producing forms of the fungus, which is a species of *Guignardia,* very closely related to the species which produces the black-rot of the grape. The spores produced upon the young berries are the probable source of infection of most of the other fruit. This fungus, which is represented in its various forms, produces two kinds of fruit, or, in other words, passes through two stages of development. The earliest stage, called the pycnidial form, produces its spores in small black spherical receptacles. The spores are furnished with an appendage at the end. This fruiting form of the fungus is the most abundant, and it is probably from this source that most of the leaves and fruits are infected. The second stage in the development of the fungus is that in which the spores are produced in sacs. These are inclosed in receptacles (perithecia), as in the other stage mentioned.

Cranberry Scald.—The name scald originated as a result of the belief formerly prevalent among cranberry growers that the injury was due to the effect of the hot sun upon the berries when they were wet, thus producing what was regarded as a real scalding of the tissues of the fruit. Fruit which has been overflowed for a half day or more during hot weather may be injured as a result, and the effect in many instances closely resembles that produced by the scald fungus. A microscopic examination of the berries shows at once the difference. In the berry which has been affected by being covered with water no fungous threads or filaments can be found, whereas in the case of the berry attacked by the scald fungus an abundance of such filaments may readily be observed in the pulp of the diseased berry. Only in the rarest instances does the scald fungus fruit on the berries after they have become half grown.

The disease first becomes noticeable as a small light-colored softened spot on the surface of the berry. This spot rapidly increases in circumference and finally envelops the whole fruit. Sometimes the diseased portion shows more or less distinct brownish zones. In other cases the zones are lacking and the whole fruit becomes very soft and has a light watery color. In many instances it is very difficult to tell from the external appearance only whether the disease is due to the scald fungus or the rot fungus.

Cranberry Rot.—Cranberry rot has until recently been confused with and attributed to the same cause as the scald. Its effect upon the berry is very similar to that of the scald fungus. It is produced, however, by a quite different species of parasite, though belonging to the same large group known as the black fungi. In some cases where the fruit is in an advanced stage of the disease, the presence of this fungus is indicated by the occurrence of irregular black blotches just beneath the skin of the diseased portion. The amount of injury from the rot is apparently not so great as that from the scald.

Cranberry Anthracnose.—Cranberry anthracnose seems to cause less damage in New Jersey than either of the other diseases just described, but it appears to be more common in Massachusetts and other New England cranberry meadows. It is caused by a species of *Glœosporium,* which closely resembles the species so injurious to the apple and other fruits. The effect of the fungus upon the fruit is very similar to that of the scald and rot, and can be distinguished from them with certainty only by careful examination or cultures made from the tissues of the diseased berries. All these diseases attack not only the fruit but the leaves. They rarely produce their spores on the leaves until they have fallen or the plant has been entirely killed by the fungi or by some other cause.

Only preventive measures are available at present in combating these diseases. After the parasites have once entered the tissues of the plant they are practically beyond the reach of remedies. Hence, efforts must be devoted to protecting the plants and keeping them in the maximum condition of health and vigor, as in this condition they are most capable of resisting disease.

It has been frequently noticed that the plants on certain cranberry meadows and portions of meadows suffer much more from rot and scald than others. This is no doubt due in great part, in many cases at least, to the soil and water conditions under which the plants are growing. From personal observations and the experiences of growers it is the opinion of the writer that in the majority of cases the control of the water supply is the most important single factor.

Just what the best quantity of water is and the best way in which to distribute it can only be determined by study and experiment in each case, and will depend largely upon the nature of the soil and subsoil and the nature, contour, and drainage of the land. In general, it may be said that the water supply should be from a reservoir, if possible, and so controlled as to avoid any great fluctuations in the quantity supplied to the plants during the growing season. The cranberry is by nature a water-loving plant, and seems to suffer more frequently from a lack of water than from an excess.

Another preventive measure of importance is the destruction of all dead vines and leaves. Frequently small areas of vines die, apparently from the attacks of the cranberry fungi. All such vines should be pulled or cut and collected early in the spring, at least within two weeks after the water has been drawn from the bog, and burned. Vines which have been cut in raking bogs to prepare them for scooping should also be treated in the same manner. Such vines if not destroyed invariably produce the spores of the cranberry fungi in great quantities and a fertile source of infection for the young leaves and fruit. Little is to be feared from the rotten berries which have reached maturity, as the fungi very rarely produces any spores on such berries.

It is a matter of common observation among growers that some varieties rot or scald worse than others. Hence, in setting new bogs or replanting old ones the most hardy varieties should be used. By giving careful attention to the selection of disease-resistant plants for propagation, a practically immune variety can probably be eventually secured.—(F. B. 221.)

Summary.—The cranberry blast, scald, and rot are caused by parasitic fungi. Spraying experiments have demonstrated that these diseases can be controlled by a proper application of Bordeaux mixture. To make the mixture effective it must be carefully prepared and thoroughly applied, with the addition of resin-fishoil soap or some other spreading and adhesive mixture. Careless or partial spraying is worse than useless. At least five applications should be made during the season. No interval of more than fifteen days should elapse between the applications. The last application should not be made earlier than August 15. It is necessary to use at least four barrels per acre at each spraying. The fruit and vines must be thoroughly covered in order to protect them. The barrel and cart or barrel and wagon spraying outfit, with two 20-foot lengths of hose, has been found most satisfactory. The cost per acre for spraying five times during the season should not, according to the methods described here, exceed $15.—(F. B. 221.)

CURRANT DISEASES.

Leaf-Spot of Currants.—This is referable to two species of fungi *(Septoria ribis; Cercospora angulata)* of which only the Septoria has been discovered in Ohio. These fungi produce early spotting and premature dropping of the currant foliage; in some instances the leaves drop even before the fruit has ripened. Bordeaux mixture applied is effective against this disease, though late applications may render it necessary to wash the fruit. For this reason, if for no other, the first application should be made very early and followed by about two more at fortnightly intervals.

Rust.—A rather common rust fungus *(Puccinia ribis)* has been discovered upon currant. Warning has been recently sent out against a second fungus *(Cronartium ribicolum Peridermium strobi)* which attacks the seedlings of white pine in the aecidial stage, and passes its uredo and teleuto stages *upon the leaves of currants and gooseberries.* This fungus is to be sought for with care since its occurence in the United States may have much to do with the success of forest plantings of white pine.—(Ohio E. S. B. 214.)

Cane Blight.—The first effects of acute disease in the plant are seen in the wilting of the foliage, and the premature coloration of the fruits. The leaves turn yellow, dry up and fall away. The fruit clusters on affected plants and usually much smaller and more thinly fruited than on healthy ones, while the berries are colored prematurely, shrivel and fall away with the leaves, so that the canes are barren. The latter then die rapidly and soon dry up. Frequently the central canes of the bush die in the manner described, while the outer ones still retain their leaves. In nearly all such instances, however, the leaves of the living parts show indications of disease. Sometimes the plants die before the leaves unfold, so that the unopened flower and leaf buds may be seen upon the dead branches. In the worst cases, where all the canes are dead, the roots also die. Occasional instances were noted where fresh sprouts had been sent up around the base of the diseased canes.

The only positive remedy that can be suggested is the removal of the whole plant as soon as the disease begins to be manifested in the yellow foliage and prematurely colored fruits. The diseased plants should be burned, as the spores and conidia may be produced in abundance on dead plants and the trouble communicated to living bushes.—(N. Y. [Ithaca] E. S. B. 125.)

Mildew—(See page 491).

DISEASES OF GRAPES.

Black Rot.—This is the most generally distributed and destructive fungous disease of the grape in the region east of the Rocky Mountains. It is caused by a parasitic fungus known as *Guignardia bidwellii.* It gains entrance to the plant by means of minute germs called spores. These are borne in small black spore cases, and can not be seen with the naked eye. They are distributed chiefly by the wind and rain. When these spores come in contact with the young and tender parts of the vine, under favorable conditions, they germinate and produce a slender tube, which penetrates the tissue and may destroy it.

This disease attacks the leaves and shoots, as well as the fruit. It usually makes its first appearance on the leaves and young shoots, producing reddish-brown dead spots. The fruit may be attacked when young, but usually the disease does not attract attention until the berries are half grown or more. Brown or blackish spots first appear; these spread and soon affect the whole berry, which becomes black and shriveled. These diseased berries remain attached to the vine, and their surfaces become covered with minute black pustules, which contain the summer spores of the fungus. During the winter and spring another form, called the winter, or resting spore, is produced upon these old, shriveled berries. These spores help to carry the disease over from one season to another. This fact would indicate the desirability of destroying, by burning, all diseased fruit, as well as leaves and prunings, as early in the spring as possible.

This disease can be effectually controlled by thorough spraying with Bordeaux mixture. Five or six applications are usually necessary during the season, the first being made just before the buds open. For the last one or two applications, some fungicide which does not stain the fruit should be used. Burgundy mixture is recommended for this purpose. Full directions regarding the preparation of the fungicides and the times of application will be found later.

Covering the bunches of grapes with paper bags soon after the blossoms fall is a means of preventing black-rot and most other fungous parasites. It is usually regarded as too laborious and expensive for the large vineyards, but may be profitably practiced where only a small number of vines are grown.

Downy Mildew.—This disease in certain seasons and in northern localities sometimes causes more loss than black-rot and is a close rival for first place among the fungous enemies of the grape. It attacks all the tender growing parts of the vine. Usually it is at first most noticeable on the foliage, producing greenish yellow, irregular spots upon the upper surface, which become reddish brown. At the same time there appears on the under surface of the leaf a thin, loose, white, downy growth, suggestive of hoar frost. This growth consists of the fertile fungous filaments bearing the summer spores which under favorable conditions are distributed by the wind and water to the berries and other parts, where they germinate, penetrate the tissues, and continue their destructive work. The young shoots are also frequently attacked and killed.

The fruit, if attacked when young or only partly grown, shows first a brownish spot, and later becomes covered with the gray, downy growth of the fungus. This form of the disease is sometimes called gray-rot by vineyardists. When the berries escape the disease until they are half grown or more it appears as a brownish or brownish purple spot which spreads and soon involves the whole berry. The affected fruit becomes soft and wrinkled and falls to the ground when disturbed. This stage of the disease is sometimes called brown-rot.

Besides the summer spores mentioned, there is also produced within the diseased tissues another form of reproductive body, sometimes called a winter or resting spore. These spores are produced in much smaller numbers than the summer spores and are provided with a rather thick, dark-colored outer covering apparently intended for their protection during the winter.

This disease, like the black-rot and many others, develops most rapidly and does most injury during hot, wet weather. It is desirable to destroy as many as possible of the diseased leaves, shoots, and berries, which may contain the winter spores. Thorough spraying, as recommended for the black-rot, will effectually control this disease.—(F. B. 284.)

Powdery Mildew.—This rarely causes great loss to American varieties of grapes. It is most severe on the European, or vinifera, grapes. This mildew belongs to a group of fungi quite different from the downy mildew. It differs from all other parasites which attack the grape in its superficial habit of growth. The filaments of the fungus do not invade the tissues of the plant to destroy them. The parasite obtains its nutriment by means of sucker-like organs which penetrate the cell walls of the surface layer of tissue only. The fine, white filaments of the fungus, which constitute the vegetative portion of the parasite, spread over the surface of the leaves, shoots, and fruit, and send up short, irregular branches upon which immense numbers of summer spores are produced in short chains. These are most noticeable upon the upper surface of the leaf, giving it a fine gray, powdery, or mealy appearance. Finally the affected part of the leaf becomes light brown, and if the disease be severe the leaves fall. The fungus produces a similar appearance upon the young shoots. Berries which are attacked take on a gray, scurfy appearance, become specked with brown, and fail to develop further. Affected grapes when nearly half grown sometimes burst open on one side, exposing the seeds. The fruit does not become softened and shrunken as when attacked by the downy mildew. The powdery mildew is usually more prevalent during dry, hot seasons than in wet ones. It differs in this respect from most of the other grape diseases. In California this is the principal fungous disease of the grape.

Bordeaux mixture, as recommended for the black-rot, will prevent this disease. Where this trouble alone is to be combated it may be successfully done by dusting with flowers of sulphur. East of the Rocky Mountains, however, it should be treated with Bordeaux mixture, as it is rarely likely to occur alone.—(F. B. 284.)

Anthracnose.—Anthracnose *(Sphaceloma ampelinum)* has also been called bird's eye rot, on account of the peculiar spots it produces upon affected grapes. Like most of the other diseases of the grape, it attacks the leaves and shoots as well as the fruit. On the leaves it at first appears as minute, irregular, dark brown, slightly sunken spots, having a darker margin. These spots usually become lighter colored when old, and frequently crack or fall out, leaving irregular holes in the leaves. This disease presents much the same appearance on the shoots as on the leaves, though the spots are frequently larger and more sunken. They also tend to run together and form irregular patches.

The disease is most characteristic and conspicuous upon the fruit. The spots are usually brown at first and surrounded by a narrow, dark purplish margin; they increase in size and gradually become grayish white and somewhat sunken. Frequently two or more spots unite and cover a considerable part of the berry. The affected tissues do not become softened, as in the case of the downy mildew, but the fruit becomes hard and more or less wrinkled. If only a small part of the berry is affected it may continue to grow, causing the diseased area to rupture and the seeds to become exposed. The bursting of the berries and the exposure of the seeds may, however, be produced by other causes, such as the powdery mildew and certain physiological disturbances.

On the diseased areas the minute spores or germs of the fungus are frequently produced in immense numbers. The fine, thread-like filaments which constitute the vegetative part of the parasite live during the winter in the tissues of the vines and are ready for active growth in the spring.

The anthracnose is quite widely distributed in this country, but fortunately has not caused any great general loss. It should be carefully watched, however, as, when once well established under favorable conditions, its eradication is very difficult. Certain varieties, such as Diamond, Brighton, Agawam, and Salem, are especially susceptible to this disease.

All diseased shoots should be cut and burned, as it is believed that it is through these that the disease is chiefly transmitted each season. Spraying with Bordeaux mixture, as recommended for black-rot, when accompanied by thorough cutting and burning of diseased parts, is likely to prove sufficient, except where the disease is unusually severe, in which case the treatment which has been adopted and found very successful in Europe may be followed. This consists of the application of the following mixture:

Sulphate of iron (copperas)............pounds..110
Sulphuric acid, commercial...............quart.. 1
Hot Water............................gallons.. 26

First pour the acid upon the copperas and then add the water. This mixture should be prepared and handled with great care, as it is exceedingly caustic and will injure the skin, clothing, and almost everything with which it comes in contact. On this account it cannot be applied with a common spray pump. A swab, made by attaching a bundle of rags to a stick, may be used in applying the mixture. All portions of the vines should be thoroughly covered with this preparation just before the buds begin to swell in the spring.

Ripe-Rot.—This has also been called bitter-rot. As the present name indicates, the disease usually appears on the fruit when the latter is nearly mature, and under favorable conditions continues its development and destruction after the grapes are picked. It also attacks the leaves and stems, but is most noticeable and injurious on the fruit. The first indication of the disease is the appearance of reddish-brown discolored spots, which spread and finally extend over the whole fruit. The surface then becomes dotted with dark, slightly elevated pustules, in which the spores are borne. At this stage of development this disease is not easily distinguished from the early stages of black-rot and bitter-rot. The berries do not shrivel up, however, as in the case of the black-rot, and usually are easily detached from the bunch. The spores mentioned are produced in large numbers and serve to spread the disease. It is difficult to determine how much injury is done by this disease on account of the liability of confusing it with other fungous troubles. It is quite generally distributed, and may cause more loss than is usually attributed to it. Spraying as recommended for black-rot will largely prevent this disease. The later applications are especially important and should be very thorough.

Bitter-Rot.—This is caused by a fungus known as *Melanconium fuligineum.* Fruit attacked by this disease presents an appearance quite similar to that produced by the ripe-rot. Bitter-rot is no doubt sometimes confused with other diseases. It is mostly restricted to the Southern States, and is not generally regarded as serious. Spraying as for black-rot will probably prevent this disease.

White-Rot.—The effect of the disease known as white-rot *(Coniothyrium diplodiella)* upon the fruit of the grape is somewhat

The San Jose Scale and Its Work. Fig. 1. Peach Tree with Top Killed by Scale. Fig. 2. Peach Twig Moderately Infested, Showing Male and Female Scale. Fig. 3. Peach Limb Badly Infested with Scale. Fig. 2. Enlarged Four Times. Fig. 3. Enlarged Twice. Dept. of Agr.

(See page 34.)

similar to that of the brown-rot form of the downy mildew. It occurs in Missouri and the Southwest and has been reported as rather serious in some parts of Ohio. There is nothing in the nature of this disease, so far as known, to indicate that it can not be satisfactorily controlled by the treatment recommended for black-rot. Sufficient knowledge of this subject to justify a positive statement in regard to treatment is not at present available.—(F. B. 284.)

California Vine Disease.—Several vine diseases occur on the Pacific coast which cause heavy losses. The most serious one, however, is the California vine disease, which has already killed more than 30,000 acres of the most thrifty and productive vineyards. This disease may be placed among the most destructive as well as the most obscure of all plant maladies. Considering its injurious nature, the obscurity of its cause, and the extent of its ravages, it may be classed with peach yellows.

The effects of the disease are seen the first season on the foliage of the vine, but by the second season a reduced growth of the cane is apparent. Taking the Muscat of Alexandria as an illustration of the behavior of the disease, when the leaves of this variety are attacked small yellow spots appear in the tissue between the main veins; as these spots enlarge they often unite, forming yellow strips, which broaden and die at the center. Eventually there is a well-marked brown stripe of dead tissue, bordered by yellow on each side, leaving only a narrow band of green tissue along the veins. After this the leaves fall, and as a result the immature portions of the canes turn black and die. The next season the growth is short. Often the color of the foliage is normal in the spring, becoming spotted during the heat of summer, after which the premature fall of the leaves and the death of the canes ensue as before. The following spring the vine may fail to put forth new growth, or it may grow until the heat of the summer and then die. This is a typical illustration of the progress of the malady, which works in many ways. In some instances the diseased vines appear perfectly healthy up to the time of the vintage, when they suddenly die; in other cases they live from three to five years.

The roots also show the diseased state of the vine at an early period; the growing points shrink and the rootcap begins to decay. This decay is most apparent in the parenchyma or soft tissue surrounding the wood bundles of the smaller roots. The soft parts rot to such an extent that the cortical portion of the root may be easily stripped from the wood. This decay progresses until nearly the whole root system is involved.

When the malady first appears in a vineyard its attacks seem sporadic. The disease will show on a vine here and there or on several vines in one section of the vineyard where some unfavorable soil condition weakens the stocks. Gradually other vines become affected, and the disease continues to progress and its virulence becomes more marked, until finally the vineyard is worthless.

Studies of this malady have revealed the fact that cuttings from diseased vines are themselves diseased, and that the degree or amount of disease in the cutting is proportionate to the degree or stage of the disease in the parent vine. Cuttings from diseased vines may root well and produce a fine, healthy-looking top, especially in the spring, but as the heat of the season approaches these young vines show disease, dying earlier or later, according to the length of time the parent vine has been affected. The disease is also found to be cumulative in its action. The longer the vine lives the more obvious becomes its unhealthy condition, the vitality of the plant being gradually overcome.

When the disease was most virulent it was learned that vines grown from healthy cuttings procured from outside of infected districts would also contract the malady and die. As time passed, however, it lost much of this virulence, and the setting of healthy cuttings can now be recommended with more confidence than formerly. Numerous vineyards are growing and bearing well which were started from healthy vines, while the disease is still apparent in many vineyards set from cuttings procured within the infected district.

Powdery Mildew.—This is one of the most common fungous diseases of the vine. It is present in nearly all the grape-growing countries of the world, but is most destructive in warm and humid localities; for instance, near the sea. In California it was known as early as 1860 or 1861, and is now present in most of the vineyards along the coast. This fungus grows on the canes, the leaves, and the fruit; its greatest injury, however, is done to the latter, as it checks the growth of the berry, either entirely or on one side, the parts affected becoming hard. When one side only is attacked the further growth of the berry causes the dried surface to burst open, wholly destroying the fruit.

Powdery mildew has two kinds of reproductive bodies or spores, one for rapid summer distribution and the other to preserve the fungus over winter. In the warmer portions of the Pacific coast the summer spores are the only ones commonly observed. When abundant they give a whitish, powdery appearance to the parts of the host affected, and it is from this appearance the fungus derives its name. These white summer spores are called conidia. The winter fruits are produced on the approach of cold weather, and, unlike those of summer, are thick-walled, blackish bodies, securely inclosing and protecting the delicate spores. They are more or less abundant according to the climate where the vine is grown.

This disease can be easily treated, owing to the fact that the vital portions of the fungus grow upon the surface, making possible the use of remedies as well as preventives.

Erinose of Grape.—Erinose is a disease of the vine characterized by swellings on the upper surface of the leaves, and corresponding depressions on the lower surface. These swellings, when numerous, cause considerable deformation of the leaves, but not the change of color to yellow or brown which is characteristic of most fungous diseases. Even very badly-affected leaves retain almost their normal green color until late in the season. The depressions on the under side are coated with a thick felt-like covering, which, at first pure white, gradually turns rusty and finally becomes dark brown. Generally, the swellings and corresponding depressions are isolated and few in number on the affected leaves, but in severe cases they are numerous enough to become confluent, and the whole lower surface is then completely hidden by the felt-like covering. Occasionally, indeed, the felt-like material extends to the upper surface in narrow strips bordering the veins, and may even be found on the petioles and flower clusters.

Most of the specimens received at the laboratory were sent under the impression that they were attacked by a fungus, and, in fact, the coating has a strong superficial resemblance to some fungous growths. A microscopic examination shows, however, that it consists of a mass of hypertrophied hairs or abnormal outgrowths of the epidermal cells of the leaf. They are larger, more abundant, and more persistent than the normal leaf-hairs of the leaf, and differ also in being often branched and usually unicellular. This abnormal growth, in common with similar growths found on other plants, is called an *erineum,* from a Greek word meaning woolly. This is the derivation of the word Erinose, which means woolly disease, a very appropriate name. The erinea of leaves were formerly supposed to be of fungous origin, but are now known to be due to the attacks of minute mites. The stings or punctures of these mites exert a stimulating effect upon the epidermal cells of the leaf, which causes them to grow out into the abnormal hair-like processes already described.

Since sulfuring the vines for the treatment of oidium has become general in France there has been little trouble with erinose. The phytoptus seems as sensitive to the fumes of sulfur as the red spider, and several sulfurings during the late spring and early summer are recommended for the control of the mite. The only vineyards which have been found badly affected in California are those in which little or no sulfuring has been done, or those where the growth of foliage has been so luxuriant as to prevent the evaporation of the sulfur by the sun. In the latter cases the vines are so strong that they practically receive no harm from the disease. In severe cases a winter treatment of the vine stumps is practiced in France. This treatment consists in pouring about one quart of boiling water over the stump. For very large stumps a somewhat greater amount of water is used, and for smaller vines a proportionate amount. This method is said to be very efficacious, and with the portable boilers constructed for the purpose two men can treat from 1500 to 2000 vines per day. Cuttings taken from affected vines for the purpose of rooting or grafting may be thoroughly disinfected by placing them in hot water (122° F.) for ten minutes. If this is done carefully all the mites and their eggs will be destroyed without injury to the cuttings.—(Cal. E. S. B. 136.)

Necrosis of the Grape Vine.—There are many signs by which the disease may be recognized in the field:

(a). A trimmed and tied vine that has failed to put out shoots. Such a vine usually splits open longitudinally during hot weather.

(b). A vine that has sent forth shoots, the latter dying after a few weeks.

(c). Vines on which all or part of the shoots and leaves exhibit a dwarfing; internodes short and leaves very small and often crimped about the margin. This symptom is observable from a distance.

(d). Leaves of nearly normal size showing a blanched or chlorotic condition and often crimped about the margin.

(e). Apparently healthy vines with leaves and fruit shriveling away and dying in the middle of or late in the summer.

(f). The presence of fleshy or corky excrescences on the stem and arms during the summer; in the autumn these dry down and become reddish brown and the following spring slough off. They have somewhat the appearance of new growth to heal a wound and are in longitudinal ribs, 1-6 inches long; globose, tumorous bodies ½-3 inches in diameter, on one side of the stem, or a gnarled growth encircling the stem near the base.

(g). The presence of minute black pimples, fruiting bodies of a fungus, on a dead spur, on dead bark or on dead wood under the bark.

(h). The presence of small reddish brown spots on the green shoots. The spots may be one-eighth of an inch in diameter and distinct; anastomosed to form a continuous diseased area sometimes extending for an inch or more up and down and half-way round the shoot; or in narrow, v-shaped, longitudinal slits.

(i). Any of the above conditions may refer to one arm only, and any vine may show only a few to nearly all of the conditions named.

The thorough spraying of the trunks and green shoots of the vines late in May and early June would be of value in preventing new infections from the spores developed at that time. Many vineyards spray for fungous rots and insect pests, and it would be an easy matter to give the trunks a little more attention. For those who spray for insect pests alone it would not be a great deal more expensive to make up the insect poison in Bordeaux mixture, using the same proportions as though the Bordeaux mixture were water.

Since a vine once diseased is almost sure to die sooner or later, eradication would seem to be one of the best means of control. A diseased vine left in the vineyard is a menace to its neighbors and may be the center for a general infection. Eradication of this disease means the renewal of the entire vine or of only a part of it. —N. Y. [Ithaca] E. S. B. 263.)

Crown-Gall.—This is a disease of somewhat uncertain origin, characterized by the formation of rough outgrowths, or excrescences, on the vines, usually near the surface of the soil. Certain forms at least are known to be contagious. All plants bearing galls should be burned, and great care should be exercised to avoid planting diseased stock. Fungicides are apparently useless in combating this disease.

Root-Rot.—The roots of the grape are known to be attacked by several different fungi, especially when the root system has become weakened or injured by other causes. Two forms of root-rot are of sufficient importance to be mentioned here. The fungus known as *Vibrissea hypogæa* is usually associated with insect injury, caused either by Phylloxera or by the grape root-worm. It has been found in New York, Pennsylvania, and Missouri, and appears to hasten the death of plants, especially those on which the root-worm has been at work. This root-rot can be prevented only by the destruction of the insects which injure the root system and thus give the fungus opportunity to gain a foothold.

There is a root-rot of a more serious nature prevalent in and chiefly restricted to Texas and New Mexico. This is caused by a fungus known as Ozonium, which also attacks the roots of cotton and a great variety of other plants. It is most destructive in the black waxy, clay soils, which are very poorly aerated. Plants attacked die suddenly, the leaves and fruit withering up in a day or two and remaining on the vines.

No remedy is known for this root-rot of the grape. Soil upon which other plants have died with the same disease should be carefully avoided in planting vines.

Shelling.—The shelling or dropping of grapes from the bunches before maturity may be due to various causes. In some localities in New York and Pennsylvania this trouble is rather serious. The cases which the Department has had an opportunity to study have been found to be due mostly to an imperfectly known fungous disease which appears to be induced chiefly by improper pruning and training. Allowing the vines to produce too heavy crops is also likely to increase this trouble.—(F. B. 284.)

Stem Cankers.—Stem cankers of the grape are rather frequent. Many of these are due to injury caused by freezing by which dead spots are produced and in the process of healing these injuries become surrounded by excessive growth and enlargements. In some instances the enlargements obtained a diameter of two or three times the size of the stem. The preventive measures are the same as for any freezing injury, viz., drainage and prevention of excessive late growth.—(Ohio E. S. B. 214.)

TROPICAL AND SUB-TROPICAL FRUIT DISEASES.

FIG DISEASES.

The Fig Anthracnose.—This is a disease of the fig fruit causing it to rot and to become worthless. It is caused by the same fungus which produces the very destructive bitter rot of apples in most of the apple regions—namely, *Glomerella fructigena.* This fungus has been known upon apples, grapes, and some other fruits for many years, but its presence upon figs seems not to have been noticed until recent years.

On the fruit, the appearance of the disease is not always the same. It may appear in the form of definite localized sunken lesions, or there may be a general rot of the whole fruit. However, these two forms can only be looked upon as extremes of the same thing, as there are all gradations between them. The lesions are in most respects similar to those formed upon the apple by the same fungus. The lesions which are sunken discolored spots on the surface of the fruit, are at first small, but rapidly increase in size and bear, as a rule, many pink, slimy masses of spores. If the fruit does not become diseased until it nearly reaches maturity, it will generally drop off the tree, shortly after the lesions begin to develop. However, if the disease attacks the fruit in a young stage of its development, it will frequently cause a drying up of the latter while it is still on the tree. These hard dried mummies hang on the trees for some time, part of them being still on the trees when the next crop sets in the following spring. The fungus remains alive on these mummies and is continually producing spores.

The leaf petioles and leaf blades occasionally also become infected with the disease, but the spots and lesions on these parts are not very abundant. The fungus also grows on dead parts of the fig tree, in wounds in the trunk, and in old cankers on the branches which were originally formed by the fig canker fungus. The anthracnose, however, is unable to produce cankers by itself on branches of the fig tree, as it does on apple trees. But its ability to grow and fruit on dead parts of the host is of great aid in keeping itself alive during periods when the fruit is not abundant on the trees. These dead parts of the tree and the mummies which hang on until spring are the principal sources of infection for the new crop of fruit.

No experimental work on the control of the disease has been conducted. But there are certain points which should be borne in mind by anyone contemplating raising figs on a large scale. The control of this disease on susceptible varieties would be very hard to accomplish. Perhaps the frequent use of some good spray would decrease the anthracnose rot to some extent, but it is very doubtful if spraying would be a paying proposition on account of the large rainfall which we have in this state. Perhaps the best method to keep this disease in check with susceptible varieties would be the careful removal of all sources of infection. This would include the removal of all of the old dried up fig mummies on the trees in the fall, and also the careful cutting away of all of the dead limbs and twigs.

But the most practical means of control is by the use of resistant varieties. Fortunately, the Celeste fig, the one that is most frequently planted, is very resistant. Unless a man has some good reason for growing some of the other figs, it would be much better for him to confine himself to the Celeste, Reine Blanche, or to some of the other fairly resistant varieties. Some of these varieties are a sure crop, producing some fruit no matter what the season may be.—(La. E. S. B. 126.)

The Fig Rust.—This is another trouble that is well known to all who have raised figs or seen them growing. This is the disease that usually causes a defoliation of the fig trees in the late summer or early fall. The leaves affected first show a number of small, raised, light salmon-colored pustules on the under surface. These increase in number until the leaf surface is practically covered. As the number of pustules become very large, the leaf begins to die, usually beginning near the margin. Later the leaf falls to the ground.

This disease is everywhere in Louisiana where the fig grows, and in probably every locality it causes a defoliation of the trees. Fortunately, however, the leaves do not usually become severely affected until the latter part of August or September, and the defoliation at this time does not seem to materially injure the crop. Occasionally the infection will come early enough to cause a shedding of some of the late figs, but this is rather unusual.

Just what effect the rust has on the vitality of the trees is hard to answer. The trees nearly always put out a fresh crop of leaves in the fall, but these are killed by the frost before they are of much service. This early defoliation, year after year, would mean the death of some kinds of trees, but the fig does not seem to be much injured. The young leaves and shoots come out in the following spring with as much vigor as ever.

This disease has long been known to be due to a fungus known as *Uredo fici,* or *Physopella fici.* How the fungus lives from year to year has not been thoroughly settled. The uredospores may live over the winter on old leaves on the ground, but if this is the case, it seems strange that the infection does not begin earlier in the season. There is no treatment for this disease that can be recommended.—(La. E. S. B. 132.)

Soft Rot of the Fig.—This is a trouble which is well known to every one who has ever raised figs. The trouble occurs chiefly during rainy spells in the summer when the fruit is ripening. The fruit sours, becomes soft and rotten, and, finally, generally falls to the ground. At the time the fruit falls, it is generally so soft that it all goes to pieces when it strikes the ground.

The rot itself is generally due to specific fungus, though there are a number of factors which govern the severity of the attack. The fungus is a very common black mold which grows on almost everything in almost every place, and known technically as *Rhizopus nigricans.* This is the same fungus which causes the foul smelling, soft rot in sweet potatoes, and it is also the same one which frequently grows on bread that has been kept too moist. In fact, it is so common on bread that it is often called Bread Mold.

There is very little that can be done to control this trouble, especially in those regions where the rainfall is large. But perhaps the loss can be decreased to some extent by following the suggestions given below:

1. Pick the figs very often, and do not allow any to hang on the trees after they are ready to pick.

2. Keep the ants out of the trees if possible. This is a difficult matter in large fig orchards, but where a man only has one or two trees on his lot and these are not in contact with any building or fence, it can be done. Perhaps the best way is by wrapping the tree trunks with something the ants will not cross, as fly paper or ant tape. Of course, this material would have to be renewed after every rain.

3. In planting the trees, use those varieties which are not particularly subject to the rot, unless there is some more important reason for using the others.—(La. E. S. B. 132.)

CITRUS DISEASES.

Foot Rot.—This is clearly marked and not likely to be confounded with any other disease. It is confined to the crown and main roots of the tree, extending a foot or so above the ground and downward along the roots. Its presence is first indicated by an exudation of gum, which forms in drops on the bark covering the diseased spot. Further examination at this time reveals a brownish coloration of the outer cortex and a decayed condition of the inner. The affected areas emit a fetid odor similar to that from a decaying orange. All plants, when attacked by a disease, strive to overcome it, and this the orange tries to do by cutting off the affected portion by a wall of new tissue similar to that formed around an ordinary wound. Following this, the bark covering the spot dries up, breaks away from the adjoining parts, and drops off. The wood is then found to be decayed for a short distance beneath.

Though the tree still continues to bear fruit, its appearance is far from healthy; the leaves become yellow, the twigs and young branches die, and the whole tree assumes an unthrifty appearance. Where the affected tree can be seen from a distance, it stands out in marked contrast to its neighbors.

Fortunately all varieties of citrus stock are not in the same degree subject to this dreaded disease. In order of foot-rot resistance they stand about as follows: Sour orange, *Citrus bigaradia;* pomelo, *C. decumana;* rough lemon, *C. sp.;* lemon, *C. limonum;* sweet orange, *C. aurantium.* Roughly, we may class the first three as decidedly resistant, the last two as very much subject to the disease. It is pre-eminently a disease of the sweet stock. We are unable to place *C. trifoliata* definitely, but would venture the opinion that it possesses considerable merit in power of resistance as well as in so many others.

Cattle-penning; deep-setting; a wet, soggy-soil condition; the use of rank, organic nitrogenous fertilizers; planting in localities underlaid with hard-pan; faulty drainage; a shaded condition of the soil, and many similar circumstances and practices have been given as the cause of foot-rot. While it is not probable that the disorder is due to any of these, there is no doubt that they have a deleterious effect on the general health of the tree, and so act as a predisposing cause. A healthy, vigorous tree has all the chances in its favor for withstanding the inroads of disease, and any decrease in its vitality simply gives its enemies an opportunity to gain a foothold. The specific cause of the disease is still in doubt, but it is probably due to some form of vegetable parasite.

As pointed out above, there are many conditions which bear an important relation to foot-rot, and a brief discussion of some of these will not be out of place. (*a*) Cattle-penning and pasturing, so often resorted to for the purpose of fertilizing the groves, is, to say the least, a questionable practice. The sharp hoofs of the animals cut and bruise the bark on the crown roots, and thus, through their agency, this possibly parasitic disease may be more rapidly carried from affected to unaffected trees. Then, too, the rank manure may act injuriously, and there is no doubt that there are better means for supplying the requisite plant food than this. In fact, we believe that the best orange is produced in Florida by the judicious use of commercial fertilizers. (*b*) Close planting is often resorted to as a means for shading the ground. A moist or damp condition of the soil is produced about the tree, which, in our warm Florida climate, is exactly suited to the development of disease. It would be decidedly better to provide a surface mulch either by the growing of leguminous crops or by providing a mulch of leaves and leaf-mold. Air would then be freely admitted, and the sunlight, one of the best germicides we have, would be allowed to reach the soil. (*c*) The piling of rubbish, old tin cans, palmetto roots, etc., about the trunks of trees is to be strongly condemned. Where a mulch of leaves or grass is placed close to the trunks it should, from time to time, be removed to allow the soil to dry out on the surface. (*d*) Strict attention should be paid to drainage, that no stagnant water be allowed among the trees. A soggy, ill-drained soil is not conducive to the health of an orange tree.

The remedies consist in removing, as far as possible, the detrimental conditions to which reference has just been made, and particular attention should be paid to everything conducive to the health of the grove. Carefully remove the earth from about the tree, avoiding injury to the healthy roots. With a sharp, strong knife, cut out all the diseased tissues down to the healthy wood. Burn the material removed. With a brush, paint the freshly cut wood, using one of the following solutions:

1. Carbolineum Avenarius.*
2. Crude carbolic acid and water in equal parts.
3. Sulphurous acid and water, three of the former to seventeen of the latter.
4. Lime, crude carbolic acid, and salt. Slake one peck of lime in two gallons of water and add crude carbolic acid, four ounces; salt, three pounds. If too thick, add a little more water.

Leave the earth removed until such time as the tree has recovered, and then it would be better to fill in with fresh, porous earth. In close-planted groves remove a sufficient number of trees to let the light reach the ground. These can be set out in another plot of ground. Disinfect cultivators, plows and harrows with carbolic acid after using them in diseased groves, and before use among healthy

*A fungicidal and insecticidal compound, used also as a wood preservative.

trees. As a preventive measure, use resistant stocks as already indicated, and where trees have died out re-set with others budded on sour orange, pomelo or rough lemon, as the soil conditions render necessary.—(Fla E. S. B. 53.)

Scab.—This citrus disease has been known in Florida for the past fifteen years or more, having been observed first on the sour orange, *C bigaradia.* The bitter-sweet and lemon are also very much subject to the disease. This year it has been collected on young, tender leaves of the pomelo, *C decumana,* and on the foliage of the Satsuma, *C nobilis* (?), and Kumquat, *C. Japonica.* A large number of young Satsuma trees badly affected by the disease were found, and the leaves showed that considerable damage had been worked by the fungus. It is not so common on the Kumquat; only a few diseased leaves were found, though several hundred trees have been examined. It is very probable that on one of the last-named varieties it was introduced into Florida from Japan, and, here finding host plants and climatic conditions adapted to its development, has become a serious inconvenience in the successful growing of certain citrus fruits.

Scabby leaves, twigs and fruit are very characteristically marked. Warty, corky elevations cover the surface, giving to it an unsightly, roughened appearance. Often the leaves are twisted or drawn out of shape, and they are in a considerable degree deprived of the power to fulfill their natural functions, namely, respiration, transpiration and the assimilation of food. Beneath the warts on the opposite side of the leaf, there is often a well marked conical depression, corresponding to the elevation on which the excrescence is situated. Under the warts on the fruit there is an abnormal thickening of the tissue resulting in the formation of somewhat conical elevations. Thus the corky portions are lifted above the normal level of the rind. The warts are at first yellowish then grayish, becoming dusky in appearance as the disease advances, until they become almost black, and eventually crack and open.

The specific cause of the disease is a minute parasitic fungus, a species of *Cladosporium* described by Prof. F. Lamson-Scribner in 1886. The spores are very small, smoky in color, and usually one- or two-, though sometimes three-celled. They are borne on brownish colored sporophores (spore-bearing filaments). When mature they become detached, and through the agency of the wind they are carried about from one tree to another. They fall upon the leaves of their host, and, under favorable conditions, germinate by sending out a delicate, slender tube, which enters the leaves and gives rise, in due time, to the well-marked diseased condition.

The experiments carried out by Webber and Swingle have gone to show that the disease can be successfully controlled by using one of the copper spraying solutions, Bordeaux mixture or ammoniacal solution of copper carbonate. The latter must receive the higher recommendation, as it is less likely to injure the tender leaves and blossoms of the lemon but a weak solution of Bordeaux mixture is likely to prove quite as efficacious without any harmful results.

To prevent scab, spray three times. Give the first application just after the petals have fallen from the first blossoms and two others inside the next six weeks. If the disease gains ground on the young fruit, further spraying will be necessary. Shoots of sour orange and diseased fruit should be removed and burned.

Ammoniacal solution: Copper carbonate, 5 ounces; ammonia, 3 pints; water, 45 gallons.

Dilute the ammonia with five gallons of water and add the copper carbonate. Use a wooden or glass vessel. Stir thoroughly until dissolved. This will give one ounce of copper carbonate to each gallon. For use, add forty gallons of water, or, in smaller quantities, one gallon of mixture to eight gallons of water.

The following mixture of Bordeaux is recommended: Copper sulphate, 4 pounds; unslaked lime, 4 pounds; water, 50 gallons.

Dissolve the copper sulphate in twenty gallons of water. Slake the lime in a small quantity of water; add water to make twenty gallons. Mix the two solutions in a third vessel or in the barrel of the spray pump, taking a pailful alternately from each of the solutions.

Die-Back.—This disease takes its name from the fact that the young twigs and branches of affected trees die back to a distance of from two to eight inches, or even more, from their tips.

No citrus trouble is more widely distributed throughout the State than die-back. No locality is exempt from it, and no variety free from its attack. Trees, young and old, suffer alike, and a few trees have been found affected which were still standing in the nursery rows. Very often little notice is taken of it, and it gradually works its way, nipping off the new growth, and the trees, in consequence, make very little progress. Years of work and much capital are often wasted in mistaken efforts to bring a grove into healthy condition.

The disease is easily recognized. The young twigs die back several inches. Irregular, reddish-brown elevations, at first closed, later cracked open and filled with a resinous substance make their appearance on the small branches and twigs. These vary greatly in length, height and shape. Often elevated pustules, filled with a gummy substance, occur on the young growth. These seem, in some cases at least, to develop into open ruptures. Adventitious buds are frequently produced, and those which are not smothered by the resinous exudation develop, thus giving rise to several branches from a single node. Sometimes the only noticeable mark of the disorder on a branch is the presence of a resinous knot in the axils of the leaves where the buds should be. Slightly affected branches have often a dark, greasy appearance. The small growth is usually twisted and bent. On the fruit the disease is manifested by the presence of dark brownish blotches and by cracking or splitting. Many fruits drop off. As the disease advances the trees try in vain to throw out new branches. Symptoms become more strongly marked, the tips of the bare, distorted branches protrude above the dark-green foliage.

Gradually the larger branches are embraced, water sprouts develop only to become affected and die. Eventually the tree succumbs.

Die-back is not, so far as known, a fungous disease, no spores nor any thing of the sort having been found connected with it. It appears rather to be a disorder brought about by a variety of circumstances, and the external marks of the disease are to be regarded as an indication of a deranged condition of the whole tree. In certain localities it seems to be brought about by the presence of hard-pan in proximity to the surface. Again, the condition seems to be due to a wet, poorly aerated soil. But perhaps the most prolific source of the trouble is the use of fertilizers unsuitable to the orange tree. Now, whether we should make a distinction in die-back as induced by these several causes, it is difficult to say.

Many instances have come under the observation of the writer, of the occurrence of the disease where trees were planted in ground previously used in growing vegetables, and which was heavily fertilized with blood and bone and cotton-seed meal. Then, too, in some localities the spaces between the tree-rows have been used for growing vegetables, the same fertilizers applied as in the cases just mentioned, and with the same deplorable effect on the orange trees. The disease has been observed in groves regularly fertilized with rank nitrogenous fertilizers, and trees standing near and receiving nutriment from stables, closets and hencoops are generally affected. The general conclusion reached by all observers during the past fifteen years or more has been for the most part to the effect that the excessive use of organic nitrogenous fertilizers will cause die-back, and the matter has been pretty thoroughly discussed in the horticultural papers of the state.

These consist for the most part in removing conditions and discontinuing practices which induce the disease. Make a thorough study of the soil and the methods of fertilizing. In some places, with trees growing on hard-pan, the following plan was adopted and they made a complete recovery: The trees were cut back, lifted from the ground, the hard-pan removed, either by blasting or picking it out, and the trees reset. The remedy for trees growing in damp ground consists in paying proper attention to drainage and fertilizing.—(Fla. E. S. B. 53).

Sooty Mold.—This is widely distributed throughout the State. It occurs as a sooty-black covering on the leaves, fruits, and twigs of many plants, and is intimately associated with various insects. In Florida it follows *Lecanium oleæ* on *Nerium oleander* and *Persea Carolinensis; Aphis gossypii* on the orange, egg-plant, and many other herbs, shrubs, and trees; *Lecanium hesperidium, Ceroplostes Floridensis* and *Aleyrodes citri* on the orange. In short, it may be said that it is found with all the scale and allied insects which exude honey-dew in any considerable quantities.

The fungus is a saprophyte, and is dependent upon this honey-dew for its sustenance. The insects already referred to are gregarious in their habits. Consequently, the honey-dew accumulates in considerable quantities on various parts of the plant, and in this substance the fungus lives. The black covering is composed of its vegetative threads. A number of different kinds of reproductive bodies are produced, and, through the agency of the wind, are carried about from tree to tree. Wherever suitable food material is found, there the fungus develops.

It is when it follows the attacks of the white-fly or mealy-wing. *Aleyrodes citri,* that the fungus most frequently causes damage in the orange groves. This insect spends a great portion of its life on the under side of the leaves. The honey-dew exuded by it, falls upon the upper sides of the leaves beneath, and upon the twigs and fruit. Whole groves are to be seen in the State to-day, the trees in which have their leaves completely covered by *Meliola.* The trees from a distance appear as though they had been coated with a liberal application of stove-black.

Sunlight is necessary to the leaves of a tree in order that they may carry out their work in the plant's economy. The black screen of fungal threads prevents the light from reaching the leaves. Their natural functions are interfered with and the tendency is to keep the tree in an unhealthy condition. Often the yield of bearing trees is greatly lessened as a direct consequence. The remedies consist of such treatments as will destroy the white-fly; that accomplished, the sooty mold no longer having food in which to develop, will disappear.—(Fla. E. S. B. 63.)

Blight.—Blight is the most dreaded of all the citrus diseases in Florida. The trees appear as though suffering from drought, or in a manner similar to ones recently set out. The leaves wilt, and droop and finally drop off. In some cases the disease works very rapidly, in others its progress is decidedly slow. It often manifests itself on a single branch and from that gradually spreads over the whole tree. Trees affected in this way live for a considerable length of time. On the other hand, it may act very rapidly; for instance, on one tree the disease commenced in a definite area on one side of the top and quickly spread both ways round the head, meeting on the opposite side. The tree in this case quickly succumbed. Usually, however, new shoots are put out, which grow well for a time, but later yield to the disease.

Up to this time the cause of blight remains unknown. It appears among old bearing trees, which are well cared for in every way, and which up to the time of attack are apparently in perfect health; therefore, it can not be assigned to any external cause. The key to the successful treatment of any plant disorder is to know the cause and nature of the ailment. This has not yet been found. Furthermore, my observations have gone to confirm those of others, that the disease is likely to spread from one tree to another. Trees once affected rarely, if ever, survive, and the best treatment is to dig out and burn the affected ones and place others in their stead. This is the most economical plan as well, because affected trees never repay the time and trouble taken with them.—(Fla. E. S. B. 63.)

Russeting Due to Rust Mites.—Russeting of the citrus fruits may be produced by one of several agents; rust mites (*Eriophyes oleivorus*), withertip fungus (*Colletotrichum glocosporioides*), and melanose. The last-named does not properly belong among the russeting, but frequently when fruits are affected by melanose in a peculiar form with the specks exceedingly minute and generally distributed, they are placed among the russets. The rust mite is not an insect, but is more closely related to the spider mites.

Rust-mite russeting is the most general affection of Florida citrus fruits. It occurs on all varieties of grapefruit and oranges, including the sour orange and even the bitter sweet (though these two varieties are nearly free from it.) When russeting is caused by rust mites, the appearance of the fruit varies from the least tinge of darkening to a nearly pitch black, with all intermediate grades. As a rule, the russeting occurs on the side toward the light, shading off to the side of the fruit next the interior of the tree. Not infrequently the side of the fruit exposed to full mid-day sunlight is also free from russeting. Fruit more or less shaded is likely to be rather evenly russeted. In dense shade the fruit is nearly always bright.

The migration of the rust mite from the leaves to the fruit does not normally occur before the latter part of April, and usually not until the middle of May. Usually much damage has been done before the grower is aware that the mites are present. The multiplication of the mites is very rapid, and in the course of two or three weeks nearly all the fruit of a grove may be affected.

Moist weather, or any condition that induces a high humidity, is likely to cause partial or complete destruction of the mites. Dry weather and conditions that induce low humidity are favorable to the development of the mites. Some hammock groves are notably free from russeting, while many pine land-groves are noted for the production of russets.

Rust-mite russeting may be distinguished from other forms by the skin being smooth and frequently shiny; while withertip russeting is dull-colored as a rule and rather rough to the feel. Melanose russeting can always be distinguished by the discoloration occurring in sharply defined dots. Any two or even all three may occur together on the same fruit. Much confusion and disappointment have arisen in recent years because many have assumed that all russeting was due to the rust mites, which is quite contrary to the facts.

Sulphur and its compounds are the substances that form the remedies *par excellence* for the destruction of rust mites and other pests belonging to this group of animals. Dry sulphur, or sulphur and lime mixed in equal parts may be applied with an air gun. This is a cheap and more or less satisfactory remedy. The soda-sulphur and lime-sulphur compounds have long been used and are still among the most efficient remedies. The self-boiled lime and sulphur should also prove an excellent remedy, but has not been tested by the writer. In using the lime sulphur solution or the soda-sulphur solution, it is not necessary to bring the insecticide in contact with the mites. Observations by means of the microscope show that these liquids do not have to come into actual contact with the mites to prove effective, the fumes being sufficient. While conducting experiments in 1910 the effect of lime-sulphur on rust mites came under observation incidentally. At the end of two and one-half hours the effect on the rust mites could be made out by means of a hand lens. In four hours' time the little pests had all collapsed, some of them not having been touched by the insecticide. Some fruits on the same tree had not been touched by the solution. On these the mites were not destroyed.

Use flowers of sulphur, or a mixture of equal parts air-slacked lime and sulphur sifted together through a flour sifter. Apply by means of an air gun. This is a simple and cheap remedy, but of varying effectiveness. Soda-sulphur solution, or lime-sulphur solution one quart to fifty gallons of water is usually effective. At the rate of one gallon to thirty of water these insecticides are likely to cause chemical scalding.

Melanose.—This is a disease of the fruit, leaves and young stems. The markings produced on these different organs are about the same. The markings on the fruit are superficial and never extend into the rind. Unless they are very plentiful, they do not affect the development of the fruit. Their presence causes the fruit to be classed as a russet, thus affecting its market value.

The markings caused by the disease are small brown spots, which are scattered like pepper over the skin of the affected part. They are circular to irregular in outline, and vary in size from mere points to spots one-sixteenth of an inch in diameter. They are wax-like in appearance, and resemble small drops of melted sugar burned to a reddish-brown color. They are raised and cap-like, and are never conical. Frequently where the markings are plentiful, they will grow together, forming solid patches of irregular outline. These patches will crack in lines like dried mud.

Some of the markings may be arranged in lines forming circles or parts of circles. The borders of the markings that make up these lines are usually peeled away. This circular arrangement of the markings is characteristic of melanose.

Again, the markings on the fruit as a whole are sometimes so arranged as to resemble the tear-streaking that is due to the wither-tip fungus. This occurs where a dead twig over-hangs the fruit, so that the drip from the twig falls upon it and runs down its side. The melanose streaking is easily recognized by the character of the markings in the streak. Fruit affected by melanose may also be affected by other diseases that mark the epidermis. The mixture of the markings due to the different causes often gives a peculiar appearance to the fruit, making it difficult to recognize the diseases.

Melanose starts its development in the spring after the warm weather has well begun. Periods of cold will delay its development. It first shows as mere sunken points, that increase in size and become raised as the fruit develops. Owing to its early stages being so inconspicuous, the disease is usually not noticed until the markings have attained some size. It shows up in its matured condition on the fruit at any time from May to July. Only young, succulent tissue is attacked by the disease. As the fruit approaches maturity, it becomes immune to attack.

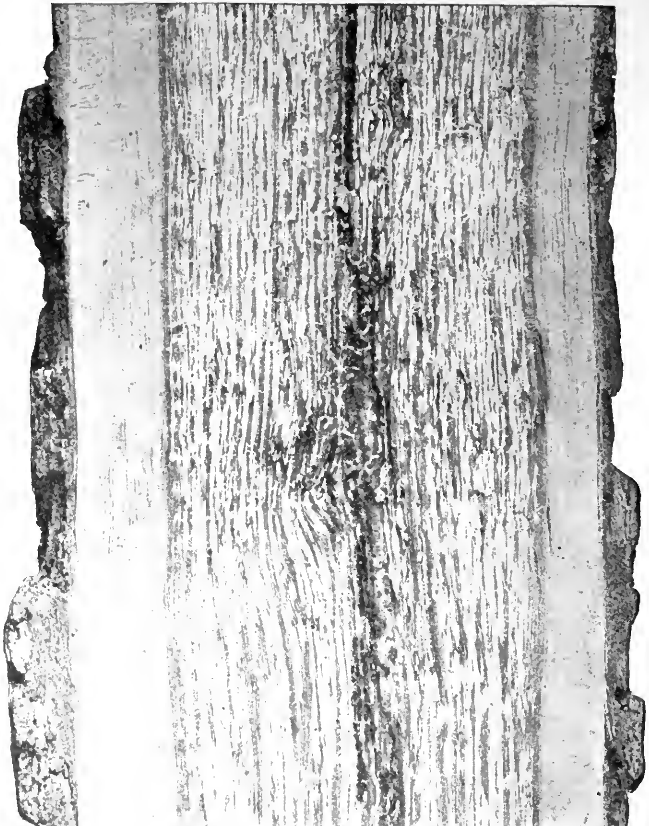
Since melanose begins to develop on the fruit in the early spring, measures for its prevention must be carried out at that time. It has been found that the disease can be controlled by the use of either Bordeaux mixture or ammoniacal solution of copper carbonate. They should be first applied about two weeks after the bloom has fallen; and again about a month later. In case periods of cold occur late in the spring, a third spraying should be made a month later still.

Russeting and Tear-Streaking Caused by Withertip Fungus.— This fungus has become a serious parasite in citrus groves during the last fifteen years. Previous to this time its occurrence in Florida was well known to botanists, but no serious damage occurred from it. Its manifestations in the grove are quite various, but only that form having the appearance of russeting will be discussed here.—(Fla. E. S. B. 108).

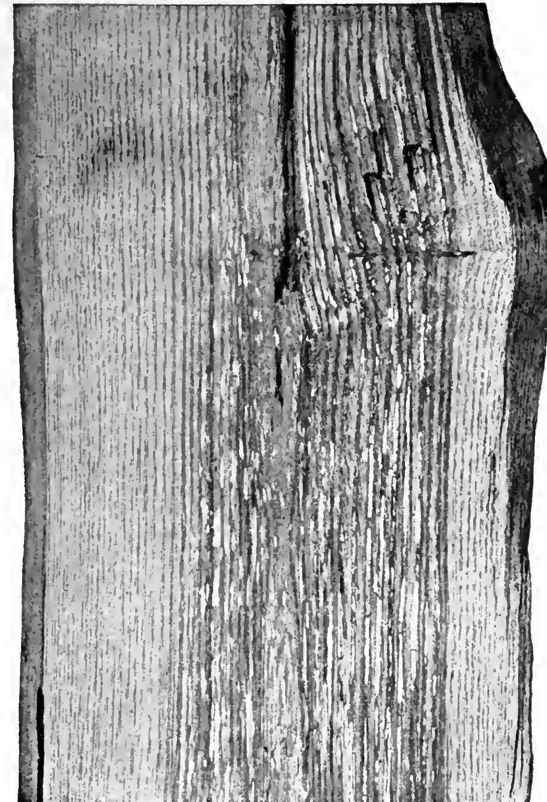
Russeting and tear-streaking can nearly always be traced back for their beginning to a small dead spur or sprig. The fungus lives in this dead spur or sprig. Water from rains, and moisture following heavy dews, collect in drops on these sprigs or spurs, and the drops, when they fall, carry with them numerous fungus spores. These spores come in contact with the epidermis of the fruits, and germinate, causing minute lesions on the epidermis too small for complete infection and production of anthracnose. It requires considerable time for withertip russeting to appear. It has not been observed to occur until the fruit has nearly matured. Tear-streaking may be produced at any time after the fruit has begun to color, and on late varieties while they are still green. Withertip russeting and tear-streaking (or streaking), being caused by the presence of fungus, can be prevented by the use of a fungicide. Bordeaux mixture and ammoniacal solution of copper carbonate are excellent for this purpose. The grower must be prepared to *fight scale insects,* however, when he uses these fungicides in his grove. In many cases the loss from russeting and tear-streaking will be less than the cost of applying the fungicide and of following that with the insecticides for destroying scale insects.

(1) The proper time to begin preventive work for withertip russeting and tear-streaking is in July, when all dead and weakened wood should be pruned out and destroyed. This reduces the amount of fungus spores to a minimum and saves the costly work of spraying.

(2) Spray with ammoniacal solution of copper carbonate as soon as russeting from withertip fungus becomes apparent. Repeat in three weeks or a month, especially if rains have occurred in the meantime and the fruit is continuing to russet. (See Anthracnose.)



Piped Rot of Oak. Dept. of Agr.



Piped Rot of Chestnut. Dept. of Agr.

Buckskin.—On fruits affected with buckskin the rind usually presents a somewhat scurfy, grayish, slightly roughened, appearance. This most frequently covers the greater part of the surface of the fruits and quite often the entire surface. The rind often becomes abnormally thick, and is pliable on maturity. The fruit is usually stunted in growth; or if of normal size, becomes light with a small amount of juice. Buckskin is usually not so rough, hard, or rusty as melanose or rust-mite russeting. It is not in definite tracts and irregular spots and lines, as are thrips marks; and it is usually much lighter in color than the tear-staining or withertip russeting. Buckskin appears to be most common in grapefruits on the interior of the tree and lower branches in shaded places. Buckskin is thought to be due to the combined effect of mites and a surface-growing fungus. It appears to have its start in an attack of mites when the fruits are very small. A fungus (which has a Coniothecium-like spore) follows the injuries in the epidermis made by the mites, and appears to be responsible for the further development of the buckskin. No recommendations based on experimental evidence are at hand, but it would seem that lime-sulphur sprays applied as soon as the mites make their appearance ought to remedy the trouble.

Thrips Marks and Silver Scurf.—Markings on the fruit known as thrips marks, also called silver scurf, are caused in most cases by thrips, but may also be caused when the fruit is quite young by other slight injuries, such as scratches or abrasions. The markings are grayish to silvery irregular patches, over which is a delicate scurf made up of minute pieces of the outer epidermis under which a new set of cells has been formed. These markings, which become quite noticeable at picking time, usually have their beginning when the fruit is very small, just after the bloom has shed. The scurfed patches are at first small, but as the fruit enlarges the areas become larger also, and a new epidermis is formed under the scurf. Sometimes the markings are so large and deep that the fruits become misshapen. Similar marks are caused by slight injuries when fruits are quite young. Spots with similar scurf are sometimes caused by a too strong spraying solution when the fruits are quite small and tender.

Those of the markings due to thrips may be prevented to a large extent by spraying to kill the thrips. As a result of experience and experiment in California (Bul. No. 99, Part 1, U. S. Dept. of Agr. Bur. Ent.) lime-sulphur with the addition of blackleaf tobacco extract, or blackleaf, "40," was found to be an efficient spray for thrips. The formulæ are as follows:

1. Lime-sulphur (33° Baumé), 1 gallon to 75 gallons of water. To this add blackleaf tobacco extract (2¾ per cent. nicotin) at the rate of 1 gallon to 100 gallons of the spraying solution.

2. Lime-sulphur, 1 gallon to 75 gallons of water. To this add blackleaf "40" at the rate of 1 gallon to 1,800 gallons of the spraying solution.

The first spraying should be done just after most of the bloom has shed. This may be followed by a second spraying 10 to 14 days later, and by a third in three or four weeks after the second. Spraying should be thorough, as only the thrips actually hit are killed. This spraying will also kill any rust mites that should happen to be present at this time of year.

Sun Scald.—This cannot be classed as a disease. It is an injury resulting from some factors that are imperfectly understood. It is generally supposed to be due to water on the fruit acting as a lens, and by collecting the light rays developing enough heat to cause injury.

This affection appears on the fruit during the late summer or early fall. It first shows as a premature yellowing of a spot near the stem end that is fully exposed to the sun. The surface may be pitted as though the oil glands had dried out. The spot is dry to the feel, and holds heat in contrast to unaffected portions of the fruit.

This affection in itself is confined to the skin. But owing to the weakening of the tissues that it produces, the fruit is attacked by fungi at this point. They penetrate the rind and cause a discoloration that may extend to the center of the fruit. Tangerines and Satsumas seem to be more susceptible to this trouble than other citrus fruits. No method of treatment has been developed, owing to lack of exact knowledge as to the cause.

Die-Back Markings.—Die-back is one of the common diseases of citrus trees. It is not due to any organism, such as a fungus or an insect, but is caused by improper feeding conditions. Some of the conditions known to aggravate the disease are: over-feeding with organic nitrogenous fertilizers, such as stable manure, cottonseed meal, and others; and unfavorable soil conditions, such as lack of drainage, or a compact subsoil of hard pan, marl, or clay, that is too near the surface. The disease is common upon certain lands in Florida, such as the shell lands, the coquina lands, and the rocky lands in the extreme southern part of the State.

Die-back affects the fruit and young stems. The symptoms on the stems are various. Fruits marked by die-back are usually spoken of as ammoniated fruit. But this may be considered as a misnomer since it gives the impression that the disease is due to too much ammonia in the soil; whereas, the disease is related only to certain forms of ammonia in the soil, namely, the organic forms.

Die-back spots on the fruit are mostly confined to the epidermis. They usually do not extend into the tissue beyond the depth of the oil glands. They vary in size from small spots 1/16 on an inch in diameter, to patches covering a large portion of the surface of the fruit. The smallest spots are usually circular in outline and conical in shape, and of a glossy brown or black color. The larger spots and patches are somewhat raised, with the surface irregularly cracked. They vary considerably in outline; some resemble thrips marks in this respect, and others cover the surface like rust-mite russeting.

The rind of die-back fruit frequently shows a great increase in thickness, and the fruit as a whole is coarse to the feel. This is supposed to be due to a too rapid growth of the fruit arising from nitrogen stimulation.—(Fla. E. S. B. 108.)

Fruit that is severely affected with die-back will show a collection of a clear to brownish colored gum in the angles of the segments next to the pith. This is conclusive evidence of the identity of the disease, as this form of gumming is only known to occur in fruits affected with die-back. The fruit on a tree severely affected with die-back is quite likely to become marked and to fall early. The fruit that remains on the tree will color and ripen prematurely, and is especially subject to splitting. The line of splitting usually develops in the discolored patches. Die-back fruit is for the most part insipid. It is unfit for shipping on account of the conspicuous markings. The marking on the fruit is usually not accompanied by any other disease that would confuse its identity.

The safest treatment for die-back consists of the removal of the conditions that are aggravating the disease, and the development of more favorable conditions for the growth of the tree. If the disease has arisen from the feeding of too much ammonia from organic sources, such as dried blood, cottonseed meal, stable manure, and others, this practice should be discontinued. Only fertilizers containing inorganic forms of nitrogen, such as nitrate of soda, sulphate of ammonia, or nitrate of potash, should be used. If the grove has been heavily fertilized, much lighter applications should be made. All cultivation should be discontinued, excepting such as is necessary to conserve the moisture. The natural growth of grass and weeds that comes on during the rainy season should be cut and removed when it is mature. This treatment should continue until the grove has entirely recovered. Under most conditions this will require from one to several years. If the condition aggravating the disease is the presence of a hardpan too near the surface, it must be broken through. This may be accomplished either by the use of hand implements or dynamite, according to its thickness.

In case the water cannot be kept down by ditches where there is lack of drainage, the tree rows should be ridged high. Lack of drainage sometimes occurs in localities that are high, owing to pockets being formed by an irregular layer of hardpan. This may be determined by systematic borings.

Where die-back occurs on shell or coquina lands, the land should not be stirred. The grass and weeds should be mowed frequently, and decaying vegetable matter should not be allowed to accumulate. Such fertilizers as cottonseed meal, dried blood, guano, stable manure and others should be avoided. This method of treatment also applies to die-back when it occurs on the rocky lands in the southern part of the State, excepting that cultivation is permissible when it is necessary to conserve the moisture.

Anthracnose.—This disease, caused by *Colletotrichum gloeosporioides,* manifests itself by brown or dark-colored sunken patches occurring in the skin of the fruit. The darkened spots may be regular or irregular in outline. The lesions may occur as a number of small spots no larger than a pin-head, or may involve a large portion of the fruit. Fruit from trees where a considerable amount of dropping has occurred should not be shipped, but the trees should be treated and the disease cured before the fruit is allowed to be picked or to come to the packing house. Not only will the infected fruit become worthless in transit, but the handling of such fruit is likely to cause infection of the healthy fruit. Infection occurs through the skin of the fruit, and is not transmitted through the tissues of the tree to the fruit.

The first sign of loss from anthracnose is the dropping of a considerable amount of fruit. This is more particularly true with grapefruit than with tangerine and round oranges. This disease, caused by *Colletotrichum gloeosporioides,* does the greatest amount of damage to grapefruit and round oranges, though it has been observed on all edible varieties of citrus fruits, including the lime. On the latter it appears in the form of scab.

It rarely occurs on fruit before it has begun to color, though in some few cases, especially with tangerines, a large percentage of the fruit has been attacked even before coloring. In such cases much fruit has become infected before severe dropping occurs. The fruit on poorly nourished and slightly debilitated trees is more subject to attack than fruit in groves that are perfectly healthy and in full leafage. Fruit on trees that are overloaded is likely to be attacked. Trees more or less affected by withertip are likely to lose considerable fruit from anthracnose. On the other hand, the fungus is not likely to make its first appearance in a grove in the form of anthracnose. Withertip fungus is present in practically every grove in the State, to a greater or less extent. One should therefore constantly expect anthracnose to appear whenever any considerable amount of dead wood occurs in the trees, or whenever there is any considerable loss of foliage.—(Fla. E. S. B. 108.)

It can be readily distinguished from the affection usually spoken of as ammoniated fruits by the fact that the anthracnose marking is always sunken and lacks luster. Spots and patches caused by ammoniation are not sunken, but are more likely to be slightly raised, and their surface looks as if varnished or oiled. Anthracnose may be distinguished from chemical injury by the fact that chemical injury, when occurring as the result of spraying, always occurs on the part of the fruit that hangs lowest, while anthracnose nearly always occurs on the upper surface or on the sides. Fruit affected with anthracnose is perfectly wholesome, and in the early stages the flavor is not affected. The following preventives will be found useful:

1. Keep the withertip fungus as much reduced as possible during the summer.
2. Avoid any treatment that is likely to reduce the foliage of the tree.
3. When withertip fungus is present in considerable abundance, or the foliage of the trees has been considerably reduced from any cause whatever, weekly inspections should be made, beginning

about the first of October. Any considerable dropping of fruit from a tree calls for immediate careful inspection. If the characteristic anthracnose lesions are found on the fruit, prompt and thorough spraying with ammoniacal solution of copper carbonate is demanded. If this work is done in a desultory manner, it might as well be left undone. Spraying with fungicide should be the last resort. Use eight ounces of pure copper carbonate in a wooden or earthen jar, and add enough water to make a thin paste. Then add three pints of twenty-six degree ammonia. This will make a deep blue liquid. Pour this liquid into fifty gallons of water. Spray the fruit thoroughly so as to moisten every part of it, but avoid using so much fungicide as will cause it to run off, which is worse than wasteful. Keep the spray from the leaves and trunks of the trees as much as practicable. Repeat the spraying in ten days or two weeks. It will take from two to four weeks before the beneficial effect of the spraying can be noticed.

Chemical Injuries.—These may arise either from a too large application of readily soluble fertilizers, or from sprays. An overlarge application of fertilizers will cause a severe dropping of the fruit. This fruit will show a dark brown to black discoloration and depression of the rind in irregular patches. The fruit as a whole will finally turn black and become mummified. Fruit thus affected differs from the rots in the more rapid development of the affection and in that it does not become soft.

Weakened and diseased fruit are the first to become affected and fall. The old leaves will show the same sort of discoloration and will fall. If the injury is not great enough to kill the branches back, the new leaves on the tree will escape injury for the most part.

The chemicals and fertilizers most commonly used that will cause this sort of injury are nitrate of soda, nitrate of potash, sulphate of ammonia, and copper sulphate.

Direct chemical injury to fruit frequently happens from the use of sprays that have been improperly mixed, or are used in a too concentrated condition. In general, the injury from the different chemical sprays is about the same. They produce a killing and depression of the tissue in the spots affected. These spots will resemble those produced by anthracnose, but are usually located at the blossom or lowest end, from the collection of the spray at this point. These spots once produced may become infected with fungi that grow inward and produce a rotting of the fruit.

Another form of spotting that is entirely different sometimes occurs where improperly mixed oil sprays have been used. This consists of a mere discoloration of the skin that shows as a circular spot of light green against the deep green of the unaffected portion of the fruit.

Sometimes a form of chemical injury occurs on young fruit from the use of sprays, which, when the fruit has matured, resembles mechanical injury. This is due to the fact that the chemical injury was slight, and the formation of the new skin and the development in size were identical with what occurs in mechanical injury. The application of a spray in the fall may be attended by a falling of the fruit if the tree is in a weakened condition from disease or unfavorable growth conditions.

There is no method of treatment for chemical injuries to the fruit after they have occurred. If the injury is due to feeding too much of readily soluble fertilizers, further application of these should be avoided until the tree recovers. Chemical injury due to overfeeding most commonly follows a heavy application of a readily soluble fertilizer followed by a heavy rain; or where too large a quantity of copper sulphate has been applied to the soil or placed beneath the bark to attempt the cure of dieback in the trees. Sprays should be mixed carefully, and applied according to directions.

Nail-Head Rust or Scaly Bark Spots.—The spots on fruit that accompany the Florida scaly bark (also known as nail-head rust) are hard, circular, sunken, more or less corky spots, causing premature coloring and dropping of fruit. The spots are at first yellowish to reddish-brown on green fruit, and finally become dark and sunken. In ringed spots the rings first become sunken with a higher part inside. This central part afterwards sinks in, and the whole area inside the ring is involved. The spots vary in breadth from one-fifth to one-half inch. These spots are found only on sweet oranges. They are not known to occur on grapefruit or tangerines. Some of the spots are quite similar to anthracnose, or to some spots produced by chemical injuries; but they may be distinguished (1) by some of the spots starting as sunken rings, (2) by grapefruits or citrus fruits other than sweet oranges not being affected even when exposed to infection.

The method of treatment for this disease will vary according to the severity of the disease and the attitude of the grower toward his grove, whether he be aiming for temporary results or be willing to sacrifice present profits for future benefits. The various lines of treatment found by experiment to be successful in controlling the trouble may be summed up as follows:

1. Top-working to grapefruit or other resistant varieties.
2. Heading back and spraying with Bordeaux, followed by an insecticide.
3. Heading back and painting with carbolineum (half strength).
4. Pruning out dead wood.
5. Spraying the fruit with fungicides, followed by insecticides. —(Fla. E. S. B. 108.)

Scab.—This disease, which is especially common on sour oranges and lemons, makes its appearance on the fruit as irregular light brown or corky projections from the surface. It is caused by a fungus which attacks the fruit or leaves when quite young. Its attack on sour oranges and lemons (and sometimes on Satsumas and grapefruit) often results in making them misshapen and unsightly. In severe attacks, projections of a dark gray to corky or even tan color will be seen extending out from the surface. The surface of the fruit between the warts is usually of a normal color. Often these irregular corky projections coalesce to form a large raised corky scab. In less severe attacks, especially when scab occurs on grapefruit and on tangerines (or rarely on sweet oranges), the warty irregular projections are wanting, and there will be seen more or less raised platform-like patches variable in shape and extent. The surface of the raised portion is finely scabbed or lightly scurfed, as is seen in the case of thrips marks or silver scurf. In this milder form it can usually be distinguished from thrips marks or other forms of scurf, by its being raised, but can be distinguished with certainty only by the use of the compound microscope.

The scab can be completely controlled by the use of weak Bordeaux mixture (3-3-50). Since the use of Bordeaux on orange trees, however, kills the friendly fungi and allows a rapid increase of scale insects or whitefly, this spray is not recommended except when it is absolutely necessary. When it must be resorted to, a good insecticide should be used as soon as the scale insects begin to increase rapidly. Some of the harm from increase of scale insects may be prevented by spraying the Bordeaux as much as possible only on the fruit, and keeping the spray off of the larger limbs and the inside of the tree where the friendly fungi may be left alive.—(Fla. E. S. B. 108.)

Splits.—Splits are fruits in which the skin and rind have broken in a line, exposing the interior of the fruit. They are caused by a development of growth pressure within the fruit accompanied by a lack of expansion of the skin and rind. This lack of expansion is due either to disease markings as in the case of fruit marked by die-back, or to a too early maturity of the skin and rind on account of unfavorable growth conditions. The splitting occurs when some point of weakness develops in the skin and rind that releases the pressure. The conditions that bring on the growth pressure within the fruit are unknown.

A case of splitting occurred on fruit growing in the greenhouse. The point of weakness in the rind was made by a chemical injury. The tree on which the fruit grew had been watered daily with a given amount during the period of development of the fruit. It is observed that if heavy rains follow a period of drought in the fall, the number of splits will be greatly increased. During the drought the fruit is soft to the feel, indicating a lack of turgidity in the cells. Following the rains, the fruit becomes quite solid, indicating a rapid increase of liquid in the fruit.

Splitting is commonly associated with disease or drought in the grove. The prevention of disease conditions will prevent the splits that develop with these conditions. Drought conditions in the grove can be avoided by the use of irrigation and of cultivation to conserve the moisture.

Creasing.—This is a form of splitting in which the peel breaks only partially, the skin remaining whole and covering the break. It is easily recognized by the feel, and can be followed with the eye by the depression of the skin along the line of break. The conditions causing creasing are probably closely related to those causing splits. Creasing has been found in abundance on trees showing a severe splitting of the fruit. On the other hand, it is found independent of fruit splitting. The remedy for creasing is essentially the same as that recommended for splitting, but it seldom becomes so serious a trouble as to require treatment. Some of the most successful growers in the State who have been troubled with this malady on their fruit have noticed that it disappears after a large application of potash.

Knots in the Rind.—This is a malady that affects both grapefruit and oranges, but has not been found in other citrus fruits. The knots show on the surface of the fruit as a slight raising of the skin, and are easily identified by their hard feel. They are gum-infiltrated spots in a thickened portion of the rind. Sometimes a gum pocket filled with a clear gum will be found in them. Nothing is known as to their origin. They occur in what are otherwise healthy fruit, and are surrounded by apparently perfectly healthy tissue.

Where the knots are very prevalent and well developed in the rind, the market value of the fruit is affected. No method of treatment or prevention has been developed, owing to lack of knowledge of the factors that cause or influence the disease.

Mechanical Injuries.—Mechanical injuries are those markings on the fruit that are due to wounds. They may be grouped into two classes: Those made when the fruit is young, which show on the mature fruit as prominent markings; and those in which the mold fungi gain entrance and cause a rotting of the fruit.

Superficial wounds may heal or dry down leaving a scar. If these wounds are made when the fruit is young, the scar increases in size with the growth of the fruit. A grasshopper was noticed biting a fruit on a tree in the greenhouse. The fruit was one and one-half inches in diameter, and the wound made was one-half inch across. The fruit was allowed to develop. When it was almost mature, the fruit was three inches in diameter, and the spot made by the grasshopper was one and one-fourth inches across. The new skin that developed over the wound had become scurfy, making the surface resemble silver scurf.

The fruit is subject to mechanical injury from the time it is picked to the time it reaches the consumer. These wounds are nearly always followed by a rotting of the fruit due to the different molds.

The minute injuries made on the fruit during its preparation for market causes the growers a loss of many thousands of dollars every year. It has been demonstrated that these injuries can be avoided. Use gloves on the hands whenever the fruit must be touched. Handle the fruit with the greatest of care. See that all surfaces that touch the fruit are perfectly smooth and that all corners are rounded. The fruit must be handled with as much care as a high explosive.

Blue Mold Rot.—This is the most prevalent kind of rot in citrus fruits of all kinds. It begins as a softening and decay at any point on the rind that has been punctured, scratched, or injured in any way. It almost never appears as long as the rind is perfectly sound and uninjured. The skin on the softened area becomes extremely soft and weak, and is covered first with a white mold, which later produces a blue-green or olive-green powdery layer of spores, giving off a smoky dust when disturbed. There are two closely related fungi, either one of which is able to produce the rot known as blue mold of citrus fruits, and quite often the two species are found together in the same decayed fruit. These two forms may be distinguished as follows: (1) *Penicillium italicum* is blue-green in color; and *Penicillium digitatum* is olive-green as seen after producing spores. (2) *Penicillium italicum* produces a patch of blue-green with only a narrow edge of white in the center of a much larger softened area not molded; while *Penicillium digitatum* produces white surface mold nearly to the extreme edges of the softened area as fast as the decay proceeds, and an olive-green patch begins at the center and enlarges. Since the blue mold follows *injuries* to fruits, it may be largely prevented by extreme care in picking, handling and packing.

The wounds through which the blue mold fungus is able to cause decay must be guarded against all along the line, from the time the fruit is being picked until it is loaded into the cars. Clipper cuts, long stems, fingernail scratches, and bruises from pouring into the field boxes, are to be avoided. In hauling, the injuries from splinters and rough edges in the boxes, bruises from the bottom of one box being in contact with the top fruit of the box below, and bruises from the jostling of the fruit over a rough road, or in wagons without springs, should be avoided. At the packing house, the further injuries that may result from rough handling, as careless emptying of the field crate from too great a height, and sharp corners of the machinery in washing, sizing and packing, are to be constantly guarded against. Poorly constructed washers, sizers and bins in such a position that the fruit is put into too violent motion, are to be avoided. In wrapping and packing, fingernail scratches are to be avoided by wearing gloves. (See Mechanical Injuries.) Not only must the slight injuries to the fruit be guarded against at every turn, but the field boxes, wagons, packing houses, and all machinery should be kept clean and free from contamination with blue mold spores from rotted fruits lying about. Packing houses in which culls or other inferior and worthless fruit are permitted to remain for even a part of a day, are pretty certain to become badly contaminated with blue mold spores. These invisible spores are carried to all parts of the structure by means of the ordinary air currents. Groves in which drops are allowed to remain also become permeated with these spores. Under the conditions which ordinarily prevail, it is almost literally true to say that blue mold spores occur everywhere.

Stem-End Rot.—Like anthracnose this disease makes its presence evident by an unusual amount of dropping. This rot begins in a circular patch about the stem end. At first the circular area is light brown or very little discolored on mature fruit, but dark brown to leather colored on immature fruit on the tree. The rind remains fairly firm at first, and the discoloration proceeds slowly from the stem end in a more or less uniform circle, and does not extend in bands. It causes a slow, and at first only slight, discoloration of the center and inner peel and partitions, and the juice sacs often remain unaffected for some time. The fruits, when entirely decayed, still keep their form more or less, but do not turn black until dried up. This rot is caused by a species of fungus hitherto undescribed. It attacks all varieties of citrus fruits, and appears to gain entrance chiefly at the stem end. It is most destructive when accompanied by scale insects under the calyx next to the stem.

The recommendations based on experiment and observation during two seasons may be summarized as follows:

(1). Pruning out and destruction of dead and diseased branches.

(2). The removal and destruction of all dropped and decayed fruits.

(3). Care at all stages of picking and handling to avoid infection from the fungus.

(4). Keeping fruit at a low temperature in transit and in storage.

(5). Spraying with insecticides to keep scale insects from attacking fruit.

Diplodia Rot.—In the early stage this rot shows as a patch about the stem end similar to stem-end rot. The discoloration becomes darker as the decay proceeds, and appears as dark wide bands corresponding to the divisions between the segments. The fruit becomes black as the decay advances and very light in weight. The rot often advances quickly through to the blossom end, and a patch of discoloration shows there before all the peel is involved. The Diplodia rot often starts also in thorn punctures or similar injuries. It is usually accompanied by the exudation of a small amount of thin gum, or a considerable amount of amber-colored sticky juice. This amber-colored juice less frequently accompanies the stem-end rot. Many of the characteristics of the two rots are so similar that for practical purposes they may be classed together. The citrus fruits are much more resistant to Diplodia rot than to stem-end rot. Diplodia rot appears to be less common on immature fruits on the tree, and the fungus causing it is less parasitic. The same line of treatment given for stem-end rot holds good for Diplodia rot.

Black Rot.—This rot begins at the blossom (or stylar) end, especially in navel oranges, but sometimes in other varieties if there be a defect at the blossom end. The fruit attacked ripens prematurely with a deep red color. This decay causes a blackening along the central core of the fruit where the segments meet and does not soften the fruit so rapidly as the previous rots. The decay is more confined to the interior of the fruit and is darker in color. The fungus enters by means of slight imperfections at the blossom end, and produces most of the decay under the skin. All diseased fruits should be destroyed.—(Fla. E. S. B. 108.)

DISEASES OF VEGETABLES.

ASPARAGUS DISEASES.

Asparagus Rust (Puccinia Asparagi).—This is caused by a fungus of the above name which is one of the true rusts or Uredineae. Like many other rusts, it appears in three different stages or forms of development. The first of these forms, called the *aecidial* or cluster cup shape, appears in early spring, but, since at that time the asparagus is being cut for market, the fungus is able to develop only upon such scattering stalks as are allowed to remain and grow up, and consequently is not at all noticeable at this season. In this stage the fungus produces little eruptions on the surface of the affected plants, each of which is a minute cavity in which numerous spores are developed in the form of long chains, which break up into separate roundish spores at maturity. These spores are carried by the wind to other plants and produce on them the second form of the rust.

Summer or Red Rust Stage.—The rust is by far the most destructive in the red rust stage which appears in July and August. The plants in the main bed have been allowed to grow up by this time and if badly affected soon appear as if scorched by fire, having a dry and withered appearance and being of a reddish brown color. The fungus consists as usual of numerous fine filaments which grow through the tissue of the plant just beneath the surface, robbing it of its nourishment and thus interfering with its vital processes. Upon the surface appear numerous little blisters which soon burst open and discharge a reddish brown powdery substance, consisting of the red or *uredospores* of the fungus. These spores fly off as a cloud of fine dust when badly rusted plants are disturbed. They are carried in enormous quantities to all neighboring plants where they germinate and spread the disease.

The Fall or Black Rust Stage.—The third form of the rust appears in September and October on plants which have survived thus far. It is characterized by the appearance of small black excrescenses upon the surface of the affected plants, which are clusters of the spores of this stage. These spores are very thick walled and thus suited to their function of surviving over winter. They remain dormant until spring when they proceed to germinate and reproduce the disease, now in the spring stage.

The best means of controlling the rust is by thorough cultivation in order to secure vigorous plants, and in seasons of extreme dryness plants growing on very dry soil with little water-retaining properties should if possible receive irrigation.—(Mass. E. S. B. 61.)

BEAN DISEASES.

Bean Anthracnose.—The anthracnose is at present the most common and destructive disease of beans. It is very probably the disease that is destroying your crop. Its most apparent injury is on the pods, where it forms large dark rusty brown or black spots. It is on this account frequently known as pod spot. The disease may and usually does occur, however, on all parts of the plant except the roots. It is caused by a fungus known to botanists as *Colletotri-*

chum lindemuthianum, which lives as a parasite in the tissues of the bean. This fungus is a plant, as much a plant as the bean on which it lives. It has a thread-like mycelium that grows into the tissue of the bean to obtain food for its growth and development and it produces spores that serve the purpose of seeds by which it spreads to healthy beans and so reproduces itself. In fighting the anthracnose fungus, we are fighting a parasitic weed, in its habits not greatly unlike the dodder which often destroys alfalfa.

The disease makes its first appearance on the bean seedlings, as they come up. It may then be detected, on at least some of the young plants, as brown discolored sunken spots or cankers on the seed-leaves or the stem. This early appearance of the disease is due to the fact that the fungus is usually carried over winter in the seed and so is already in the bean when it is planted. In severe cases the spots or cankers may be so numerous as to cause heavy loss in the seedlings and result in a poor stand. Sometimes the stem is so badly diseased or eaten near the base that it falls over and dies. Usually so few of the seedlings are attacked that the presence of the disease in a field is at first overlooked. Nevertheless, as the season advances the fungus spreads to healthy plants near by, by means of its multitude of tiny spores produced in these spots on the seedling and before the grower knows it his entire field may be badly affected.

From the spots on stem and seed-leaves of the seedlings the spores find their way to the large leaves and branches of the rapidly growing plants. The large veins of the leaf are frequently eaten through and killed by the fungus, and holes or cracks with blackened margins appear in the blade. While this may not entirely kill the leaf, it greatly lessens its efficiency as a starch maker and so indirectly but effectively reduces the yield of seed. Many times, however, the attack is so severe that the leaf stems are cut off and the entire plant is practically ruined.

It is from the attack of the disease on the pods that the most direct and apparent damage to the crop results. During the time of blossoming and previous, the fungus has been spreading and becoming established on the stems and leaves, and it now attacks the young and succulent pods. With their tender growing tissue full of water and food materials, these pods offer the best conditions for the growth and development of the parasite. Spores from the spots on the leaves and stems fall on the pods where, in the presence of moisture and the high summer temperature, they germinate, forming a little sprout or germ tube, which penetrates the tender skin of the pod and, branching in the juicy tissues, gives rise to an anthracnose canker. These first appear as little brown or rusty spots which enlarge and darken until nearly or quite black. The dead tissue dries and settles, causing a little pit or sunken place in the pod. In the center of the spot the spores of the fungus are now produced in great abundance. They ooze out and pile up, forming little pink masses easily seen with the naked eye. These masses of spores are held together by a kind of glue or mucilage which, when dry, sticks them tightly to the spot. When a drop of rain or dew falls on the spot the mucilage is at once dissolved, and the spores are set free in the water. At this time any disturbance of the bean plants will scatter these spores in the flying drops of water. In this way they reach healthy plants near by. This explains why beans should not be cultivated or handled in the early morning while the dew is still on them or directly after a shower. The spores of the anthracnose fungus are scattered only when they are wet. This will also explain why a warm rainy season is so favorable to the development of the fungus. The spores require moisture in which to be distributed and in which to germinate. A relatively high temperature is also most favorable to the disease. The spores are produced in unlimited numbers in the spots on the pod. Under favorable conditions these spores spread from pod to pod until practically every bean in a large field may be affected. Sometimes string beans that appear to be perfectly clean and free from the disease will become very badly spotted if left in boxes or bags for a short time. This frequently occurs during shipment to market. In such cases the beans are either infected before or during picking or become contaminated from a few spotted pods that have been overlooked and put into the bags with the clean beans. *No spots will appear on the leaves, stems or pods unless spores find their way to these parts of the plant.* The spores may be scattered by the cultivator, the pickers, by animals, or by the wind in damp or rainy weather.

As the threads or mycelium of the fungus penetrate deeper into the pod they finally reach the seed within. In the unripe condition the seed-coat is easily penetrated by the mycelium and the fungus is thus established directly in the seed itself. Unless the seed is entirely destroyed by the fungus, it ripens and the enclosed mycelium becomes dormant. The presence of the fungus in the seed may usually be detected by the brown or yellowish discoloration of the seed-coat. When the seeds are badly affected, they become more or less shriveled as well as discolored. It is thus easy to tell with considerable certainty whether seed to be planted is affected with anthracnose. When the seed is planted in the spring the enclosed but dormant fungus is planted with it. The moisture and warmth which stirs the bean to life awakens the fungus also. In the soft and fleshy seed-leaves in which it is imbedded the mycelium finds an abundance of food and grows rapidly, soon forming a spot or canker and producing spores which at once begin again to spread the disease to neighboring healthy plants.—(N. Y. [Cornell] E. S. B. 239.)

Selection of clean seed is of first importance in growing a clean crop. All beans to be planted should be most carefully hand picked and all beans showing discolorations, wrinkles or blisters should be discarded. *This cannot be too carefully done.* It has been found that in some cases where 95 per cent of the beans were marketable *only one per cent was fit for seed.*

As soon as the bean plants are well through the ground, they should be carefully examined and all diseased seedlings pulled up, carried from the field in a sack, and burned. This is the second step in the contest with the anthracnose and it is important, since even the most expert will overlook some of the diseased seeds in sorting.

As soon as the plants are well up, and the first pair of true leaves begins to unfold, spray thoroughly with Bordeaux mixture. Probably the best formula to use is five pounds copper sulfate, four pounds of stone lime to 50 gallons of water. A stronger solution has been found to dwarf the plants, while the weaker solution is equally as effective in preventing the anthracnose. This should be so *thoroughly applied that every part of the plant above ground will be completely covered.*

In about ten days or two weeks the plants should have a second spraying, using the same strength of mixture. This application should be as thorough as the first. This is to cover and protect the new growth of leaves and branches. Unless excessive rains wash the mixture off, it will not be necessary to spray again until the pods are forming, shortly after blossoming time. A third application of the same strength and thoroughness should now be made. The nozzles should be so arranged that the *pods as well as stems and leaves will be thoroughly coated. This is important.*—(N. Y. (Cornell) E. S. B. 239.)

In most cases three sprayings will be sufficient. If the seed was badly diseased and if the plants show an abundance of the anthracnose, more sprayings will probably be necessary to insure a clean crop. Excessive rains will also necessitate more frequent applications. The effect of heavy rains in washing off the mixture may be overcome by adding to the Bordeaux mixture the following: two pounds resin, one pound sal soda, one gallon of water. Boil together until of a clear brown color. Add one-half this amount to each barrel of the Bordeaux. An extra spraying between the second and third, and another after the third when the pods are nearly full grown, will no doubt be sufficient in the worst cases. Repeated experiments by the writer have shown that one or two thorough sprayings even after a large percentage of the plants are badly diseased will insure a comparatively clean and profitable crop.

The removal and destruction of diseased pods and stalks is also a matter not to be overlooked. While the disease is most commonly carried over in the seed, it has also been demonstrated that diseased pods and stems thrown on the fields in which beans are to be planted will result in a marked increase of the disease the next season. For this reason all diseased pods and stalks should be burned, or, if they go into the manure pile, the manure should not be put on fields in which beans are to be planted.

Cultivating or working in the beans when wet should be avoided as much as possible. As already pointed out, the spores of the disease are disseminated only when in drops of rain or dew. When dry the mucilage in which they are enclosed fastens them to the spot and they cannot be scattered. For the same reason string or snap beans should not be picked when wet. The handling of a single spotted pod may be sufficient to spread the disease throughout an entire row, or spot all the pods gathered. Repeated cropping of the same land with beans is not desirable and, fortunately, not commonly practiced.

It is well known that certain varieties are more susceptible than others to this disease. This is notably true of the common Wax varieties. So far as the writer has been able to discover, no very extensive information on this point is to be had. Numerous Rust Proof varieties have been placed on the market, but while some of them are more or less resistant probably all will spot under conditions most favorable to the fungus. Dependence, therefore, should not be placed on the resistance ability of any variety. *All should be thoroughly sprayed if immunity to the disease is desired.*

Bean Blight.—The blight is a bacterial disease. It is caused by a minute parasitic plant *(Bacterium phaseoli)* in form and habits of life quite unlike the anthracnose fungus. These tiny bacteria have no mycelial threads and no spores. Each little cell is a plant in itself. The bacteria increase in numbers by each one simply dividing into two which, when full grown repeat the process. Each one is supplied with a long fine *flagellum* or tail by which it may wiggle about to some extent in the tissues of the bean. The blight attacks the ordinary field and garden varieties and also the Lima Beans. Like the anthracnose, it attacks all parts of the bean above ground but is most conspicuous on the foliage and pods.

The first evidence of the blight is usually to be observed in the leaves. These show large brown dead patches often spreading through the entire leaf. When wet, the spot is soft and watery but when dry, becomes papery and brittle. On a badly blighted patch the leaves become dry and curled, as if scorched. The bacteria probably always enter the bean plant through a wound. Judging from some observations made last season, it seems likely that certain insects are in most cases the agents by which this disease is carried from plant to plant. This is an important point in the life history of the parasite and one that requires further observation before definite statements can be made. Having gained entrance to the leaf, the disease gradually travels down the stem to other leaves and to the pods. Professor Barlow of the Ontario Agricultural College, has shown that the progress of the disease is comparatively slow. Leaves of beans inoculated with the bacteria did not show symptoms of the disease until the third week. The bacteria increase in such numbers that finally they may fill up the sap tubes in the stem, cutting off the water supply and so cause the entire plant to wilt and die.

Through wounds or by way of the stem the bacteria find their way into the pods which, if young, may shrivel and die. In the larger pods they produce spreading watery spots which finally become more or less discolored but never sunken and black as in the case of the anthracnose.

From the pod the disease readily gains entrance to the growing seeds. The pods are not destroyed unless attacked when very young, and when ripe they may show considerable discoloration or none at all. The bacteria, however, having gained entrance into the seed, as in the case of the anthracnose, remain there dormant throughout the winter. With the germination of the seed in the spring the bacteria also begin to multiply and find their way to healthy beans and so the infection spreads.

No method of treating the seed to prevent the blight has yet been proposed and properly tested. Professor Barlow has demonstrated that the bacteria are readily killed by exposure for ten minutes to water heated to 122° F., while dry beans can endure such a temperature for some time without injury. While this gives some promise of success the treatment is open to many of the objections raised in the case of the anthracnose.

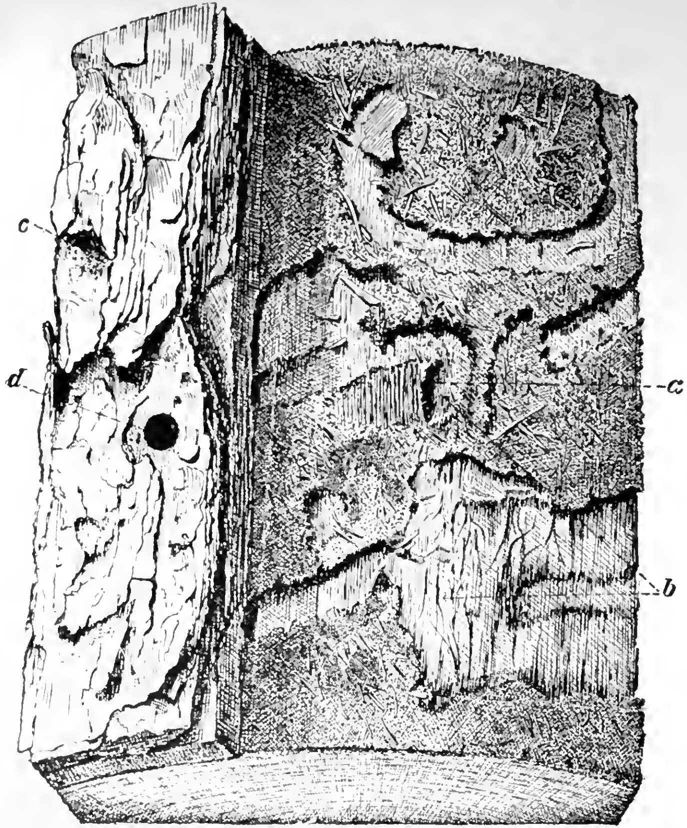
The sorting of seed affected with anthracnose has been shown to be highly desirable. Its value in the case of seed affected with blight is very questionable. Owing to the fact that blight-affected seeds are often not discolored, it is manifestly impossible to sort them from the healthy ones. The safest method is to discard all seed known to have come from fields that showed the disease.

In regard to these practices Professor Barlow says: A field where beans have sickened with this disease is unfit for growing beans for at least one season, as the germ lives over at least one winter in the stems and leaves left on the ground. How long such a field may remain infected is unknown, for we do not yet know whether the germ can live and increase in the soil where no beans are growing, although this is probable. Bean straw from infected fields may be burned. If it is fed to animals or used in bedding, the manure should be returned to the field on which the beans grew, and not spread on fields as yet free from the disease.

At the New Jersey Experiment Station, a professor has experimented for a number of years with several spray mixtures for the prevention of bean blight. The Bordeaux mixture of the strength recommended for the anthracnose has been found to be very satisfactory. Probably a larger number of applications will be necessary for the blight than for the anthracnose.

The Bean Leaf Spot.—To this disease of the bean, much more common than generally supposed, is to be charged much of the trouble ascribed to other fungi. This is the *Isariopsis griseola,* that for the lack of a common name may be called the bean leaf spot. It is quite different from the other bean diseases, in being confined chiefly to the foliage, where it produces numerous spots, usually small and angular, without any colored border. The fungus itself forms a gray, mouldy covering upon the under surface of the spot where the spores are produced in vast numbers. From the superficial nature of the spore production, it is safe to conclude that this fungus is amenable to the ordinary treatment for similar diseases. The direct testing in this instance appears to be lacking.

The Bean Leaf Blotch.—This is not uncommon in the United States, but as it only affects the foliage the crop is shortened only indirectly. This disease produces patches of a brown color upon the leaves, causing them to become useless and fall away as in other kinds of cercosporas, like that of the violet leaf spot and



Pine Sawyer Bark Removed. Channels Grooved by Larvae.
Dept. of Agr.

Living Aspen Tree with Fomeo Igniarius. Dept. of Agr.

the leaf spot of the celery. The spots of this Cercospora have an angular appearance, as with Isariopsis, from the fact that the small veins act as barriers to the fungus, as it spreads within the leaf, giving sometimes something of a checkerboard appearance to the surface of the affected leaf. The last two kinds of leaf diseases here mentioned are easily distinguished.

The Cercospora belongs to a group of fungi that is not difficult to check with fungicides, as repeated tests have shown with a common species upon the beet, and therefore the treatment which should be given for anthracnose or rust will meet the demands of the leaf blotch.—(N. J. E. S. B. 151.)

Leaf Spot on Beans and Cowpeas.—This trouble was first observed on lima beans, but has since also been found on other varieties of beans and also on cowpeas. It has been much more destructive on lima beans and cowpeas, and seemed to be quite common in Delaware wherever these plants are grown. The trouble occurs on the leaves and often so seriously injures them as to kill or greatly weaken the growing plants. On lima beans, the disease appears when the plants are about a foot high and continues to increase with the new growth. So far as my observation goes the pods are never diseased. Often reddish spots are found on the pods of lima beans.

Fungous Leaf Spot.—The fungus occurs on the leaflets of beans and cowpeas as irregular or sometimes circular rusty brown areas. These spots become with age lighter in color in the center, but the margin is still darker in color. This is true on the cowpeas as well as on the beans. The spots are for a considerable time sterile, and no spores of the fungus can at this time be found, though often various saprophytic fungi may be found growing on the spots.

No work has been done to try and control these various diseases by spraying. There seems to be no doubt but that the Bordeaux mixture properly applied would give beneficial results. Another suggestion perhaps fully as practical for the gardener or farmer is always to destroy diseased vines by fire at the end of the season. In this way many spores that remain in the tissue of the plant will be destroyed and the danger from infection next year much lessened.

Bean Rust.—The true rust of beans is, like the anthracnose, a fungous disease. It differs from the anthracnose, however, in many important respects. The most important difference from the growers' point of view is that it is a much less common and destructive disease. It occurs only on the leaves of the bean, rarely on the stems and pods. Except in very severe cases, it does not materially injure the leaves.

The rust fungus (*Uromyces appendiculaius*) sends its mycelial threads into the tissues of the bean leaf there to secure nourishment for its own growth and development. From the ends of the threads that come to the surface at certain spots, spores are formed. These are of two kinds; the summer spores, brown and forming powdery specks on the underside of the leaf which readily rub off on the hands as a rusty brown powder; the winter spores, black and produced in small compact warts on the underside of the leaf or sometimes also on the upper side. The spots on the upper side are commonly surrounded by a yellow border. The summer spores appear rather early in the season and are produced in abundance. It is by means of these spores that the disease is spread. The black winter spores appear later. They result from the late infections by the summer spores. The mycelium never spreads far from the point of infection and, unless these points are numerous, but little damage is done to the leaf. The disease winters in the old leaves.

While this disease is not common and is rarely destructive, yet it is desirable that it should not become well established on a farm. Under very favorable conditions it might become sufficiently abundant materially to injure the crop. Therefore, it is well to learn to know it and be able to stamp it out whenever it appears. Since the disease winters only in the diseased tops, it is readily exterminated by burning all diseased plants after the beans are harvested. When beans are sprayed for anthracnose this disease will also be controlled.

Apparatus for Spraying Beans.—Any sprayer that will *thoroughly cover every part of the plant* with the Bordeaux mixture may be used. It is not possible to recommend any one machine as the best for spraying beans. The kind of power used is immaterial so far as effectiveness is concerned, provided it gives sufficient pressure. The grower must decide for himself what power will be most desirable in his case. The important thing aside from the pressure is the arrangement of nozzles. Below is given a list of spraying machine manufacturers who furnish with their machines nozzle arrangements for spraying beans (probably others will also furnish them):

Niagara Sprayer Company, Middleport, N. Y. Liquefied Carbonic Gas.

The E. C. Brown Company, Rochester, N. Y. Compressed air, compressed by power from the axle.

The Gould's Manufacturing Company, Seneca Falls, N. Y. Hand power or Gasoline engine.

The Standard Harrow Company, Utica, N. Y.

Field Force Pump Co., Elmira, N. Y.

Bateman Manufacturing Co., Grenloch, N. J.

CABBAGE DISEASES.

Black Leg or Foot Rot of Cabbage.—The dissemination of this disease is not so much a matter of overlooking the planting of infected seedlings, though undoubtedly much of this takes place, as it is of general distribution of spores through the handling of occasional sick plantlets.

Plants affected with this trouble die in all stages of their growth; few, however, succumb previous to the transplanting, and only those more or less badly affected at the time of setting out die within the following three weeks. The greatest loss takes place at the time when the plants are one-half to two-thirds grown, at which time the symptoms are very characteristic. The foliage of the affected plants takes on at the margins a mottled, metallic, bluish-red color. The lower, outer leaves show evidence of wilt. Total collapse may take place in 24 to 48 hours. Examination of the stems and roots of partially matured, infected plants always reveals large, sunken lesions extending one-half to two-thirds the distance through the stem or sometimes showing a sunken collar-rot, so far destroying the stem as to allow the top to break off easily. The experimenter has experimented upon the use of both Bordeaux mixture and a straight solution of copper sulphate (bluestone) for this disease upon cabbage seed beds at time of planting and upon seedlings three weeks old. The formulas used were, for the Bordeaux, 4 lbs. copper sulphate, 4 lbs. lime, to 50 gallons of water—and in the straight copper sulphate solution, 4 lbs. of copper sulphate to 50 gallons of water.—(Ohio E. S. B. 228.)

Black Rot of Cabbage.—The first evidence of disease usually appears in the latter part of July when the more advanced plants of late cabbage are beginning to form heads. The first symptoms of an outbreak are easily recognized on a hot, dry afternoon when a number of the plants will appear wilted and lighter green in color. A cross section of the stem of these plants near the ground shows that many of the water-carrying fibro-vascular bundles are black; and on splitting the stem these black lines can be followed down to the withered extremity of the tap root. A diseased condition of any considerable number of these bundles curtails the water supply and when atmospheric conditions are favorable for rapid evaporation from the leaves the latter quickly wilt.

The upward movement of the water carries the disease along the bundles out into the leaves. As soon as the bundles supplying any considerable portion of a leaf become diseased that part of the leaf dies for lack of water. The blade of the leaf becomes light brown and has a texture like parchment. It is semi-transparent and when closely examined the network of fine veinlets which have been turned black by the disease stand out sharply in the brown background.

Early in August the disease commonly manifests itself in another form. Brown spots appear at the margin of many of the leaves, especially of those which come in contact with the soil. These brown areas spread toward the center of the leaf and a close examination shows the fine veins to be blackened. In from one to three weeks, depending on circumstances, the disease usually reaches the stem of the plant. The progress of the disease from this point is identical with that brought about by infection through the root.

In either form of infection the most reliable diagnostic character of the disease is the blackening of the fibro-vascular bundles. These bundles may be readily inspected by cutting across the leaf petiole or the stem.

The failure to supply sufficient water checks growth and often results in the death of the plant. The fibro-vascular bundles do not branch freely in the stem and in cases where the disease gains a foothold only on one side of the plant the growth on that side is retarded so as to produce a marked curvature. The lower leaves turn brown and drop off, but when the plant succeeds in forming a head the upper leaves are held in place and often turn black and decay, thus destroying the commercial value of the head.

The extreme variation in the activity of this disease in different years depends largely upon weather conditions. A combination of abundant moisture with high temperature during August and September is favorable for an epidemic.

Caused by Bacteria.—The blackening of the fibro-vascular bundles and the accompanying decrease in the water flow is due to the growth in the tissue of a bacterium known as *Pseudomonas campestris,* Smith.—(N. Y. [Ithaca] E. S. B. 232.)

Prevention of Black Rot.—No practical treatment for black rot has yet been discovered. It has been shown that the leaf-pulling treatment instead of being beneficial is positively harmful. Rotation of crops affords little if any protection against the disease. Placing the seed bed on soil which has never grown cabbage or related plants is a good practice, but it remains yet to be proven that it is of any real value as a preventive of black rot. Spraying with resin-bordeaux mixture is, perhaps, worthy of trial, but can not be relied upon to control the disease.

The virulence of the disease depends largely upon weather conditions, and it is unfortunate that the conditions most favorable to the growth of cabbage are also the most favorable to the disease. Rapidly growing plants are especially liable to be attacked.

It appears to the writers that before much progress can be made toward the control of the disease it will be necessary to determine more definitely how the germs spread from plant to plant and field to field; also, to what extent they live over winter in the soil, to what extent root infection occurs and whether the disease is transmitted through the seed.—(N. Y. [Ithaca] E. S. B. 232.)

Cabbage Club Root.—When a field is badly infected with disease, it may appear at the seedling stage as a dwarfing of the young plants, but the fields are not usually badly enough infected the first season to manifest the disease until the cabbage is half grown. In districts where the disease has just begun to get a foothold, the grower is not likely to notice any trouble, therefore, until after the first of July. At about that time it will be noticed that the plants which are being infected show a tendency to wilt on bright sunny days, although at night they recover, and do not wilt on the following day unless it is again bright and warm. Such plants may succeed in making enough growth to produce a salable cabbage, although it is somewhat undersized and slightly loose. The earlier the plant is infected with the disease, the smaller is the head produced. If the diseased plant is pulled up, one finds that it has a swollen and contorted root, in place of the fine fibrous roots of the normal plant. This explains the wilting, when one remembers that the soil and its dissolved food substances are taken up through the fibrous roots.

When the plants are infected at the seedling stage they are usually killed before the season is half over, and the infected areas may be seen entirely bare of cabbage. The swollen, contorted roots, which have robbed the plant of its food material, begin to decay in the soil in the latter part of the season and continue the process of decay, aided by frosts and soil bacterias, so that nothing of them is seen the following spring.

There is but one agent responsible for the club root disease. This is known as *Plasmodiophora brassicæ,* an organism belonging to the lowest orders of plant life.

It appears that, so far as experimental work has gone, the use of lime is distinctly beneficial in combating club root disease in the field, and that the after effects of the lime, as shown on the plot where it was applied two years previous to the experiments, are quite marked. Acid phosphate was of little use in combating the disease. Whether this is due to the slightly acid condition which it gives the soil, or whether it is due to the fact that the phosphate is favorable to the growth of the organisms, is not ascertained. Stable manure brings conditions which are decidedly favorable for the spread of the disease, because of the large amount of organic material which it introduces into the soil.

Recommendations.—1. Avoid introducing any material into the field which may carry the germs of the club root from diseased fields. Guard especially against diseased soil and diseased cabbage plants.

2. Practice crop rotations which will allow at least three years between crops of cabbage, rutabagas, or turnips.

3. Apply stable manure to the crop which precedes cabbage, but not to the cabbage crop itself. If acid phosphate is applied the same rule would hold.

4. Lime will more successfully counteract the club root disease than other substances. Apply it at the rate of 100 bushels or more per acre one or two years previous to planting the cabbage.—(Vir. E. S. B. 191.)

Fusarium Wilt or Yellows of Cabbage.—This trouble is known as yellows—this term being applied because of the external appearances. In diagnosing the disease, this color characteristic is the first symptom to be relied upon. Later, a stunted growth, with a tendency of the lower leaves to drop at the lightest touch is further evidence of the disease. To the keen observer these symptoms may be detected in the seed bed previous to transplanting. Plants which show the symptoms in the seed bed, upon being transplanted, make no further growth, they simply wilt, turn black, and the lower leaves usually fall off.

After setting out, the healthy plants are attacked at all stages of their growth. In the older and later infected plants, the preliminary symptoms are similar to those in seedlings; yellowing of the lower and outer leaves takes place; these leaves later drop, turning a drab color, the lowest first, being followed successively at different times by others in their order.

In older plants, sometimes stumps nearly full size may be seen that have shed all their leaves. This deciduous nature of the leaves is very characteristic of the Fusarium wilt. No broken lesions are to be noticed on the stems and roots unless decay (bacterial and fungous complication) follows, which does occasionally take place.

Parasitic diseases of field crops which are also persistent soil organisms seldom admit of definite treatment economically. In the case of club-root of cabbage the causal organism gradually succumbs to heavy applications of lime. Potato scab, on the other hand, is increased by lime. In the case of cabbage wilt (Fusarium) no specific treatment is known.—(Ohio E. S. B. 228.)

CELERY DISEASES.

Leaf-Spot or Leaf Blight.—This is a prevalent condition upon celery plants. This is at times attributed to the fungus above named, or others, and is also produced by other causes, as by excess of water during overflow and the like. During certain seasons the loss from the leaf-spot or leaf-blight troubles is very much greater than during others. This is clearly explained when the conditions giving rise to the leaf troubles are apparent. But this is by no means a common fact, and in some years there is much blighting after the celery has been boarded up for blanching. Usually the fungus is discoverable in diseased areas of the leaves. The use of fungicides, such as Bordeaux mixture, is likely to prove beneficial, especially to protect the plants in the seed bed until transplanted.—(Ohio E. S. B. 214.)

Celery Root Rot.—The disease seems to affect the main roots rather than the fibers. They rapidly rot off near the crown, so that the plants may be readily taken from the ground. Sometimes a few of the larger roots may be severed an inch or two from the crown, which, for the most part, alone remains and tapers to a more or less rounded point.

It seems clear, that whatever part Rhizoctonia plays in celery Root Rot, in the later stages of decay with which it is known to be associated, the primal cause is to be found in poorly drained soils. More thorough underdrainage, with sufficiently deep main ditches, is suggested as the best preventive.—(Ohio Cir. 72.)

CUCUMBER AND MELON DISEASES.

Several diseases attack the leaves of cucumbers and melons in this country. Downy mildew, leaf-blight, and anthracnose are the most common, though there are several others of less importance. The parasitic fungi which cause these troubles are quite distinct in their nature, but produce rather similar effects on the foliage. From the standpoint of the farmer they may be considered together, since the treatment for all is practically the same. It is well to know their exact characters, however, especially since there are a number of other maladies, due to bacteria, soil and climatic conditions, and to insects, which do not yield so readily to spraying, and may be confused with the diseases to be described.

Downy Mildew.—Downy mildew, the most destructive of all cucurbit diseases, is especially injurious to cucumbers, but also attacks melons, squashes, pumpkins, gourds, and other related vines.

The first indication of downy mildew in the field is a yellowing of the older leaves in the center of the plant. Faintly defined angular spots bordered by the veins will then be detected. These become more distinct, and if the weather is moist an obscure violet coating of the spores may be noticed on the under side of the spots. The disease progresses from the center of the hill outward, the young leaves at the tips of the branches living longest. It spreads slowly in bright weather, but under the more favorable conditions afforded by cloudy, humid weather it often develops with the greatest rapidity, so that the fields quickly become as if scorched by fire.

Downy mildew is caused by a parasitic fungus closely related to the destructive downy mildews of grape, onion, etc., and to the late blight of potato. So far as known, it is spread entirely by its conidia, or summer spores, produced on the lower surface of diseased leaves. These are blown about by the wind, but are very thin-walled, delicate bodies, which perish quickly when dried. No oospore or resting stage is known, and there is consequently no evidence that the fungus lives over in dead vines or in the soil, and no logical reason for destroying the vines or for selecting fresh land for the crop, aside from questions of soil fertility.

The disease lives through the winter in Florida and probably spreads northward each summer. There is also good evidence that it lives over in greenhouses, which may later become the centers of local epidemics.

The earliest appearance of the disease in South Carolina in 1905 was May 1. It usually appears in that latitude during June. It does not reach Ohio until August 1, while New York and New England are visited later in August. The date of appearance and the severity of the outbreak seem to be governed mainly by the weather. During unusually dry seasons the disease may be entirely absent, while warmth and moisture, especially warm, cloudy nights, soon lead to its development and result in the greatest loss. Any weakness of the plant appears also to predispose it to attacks of downy mildew. Cold weather during spring, when the plants are small, is unfavorable for this reason. The plant also becomes more susceptible when the bearing of fruit is imposing an additional strain upon it. Liberal fertilizing and careful attention to cultivation should be given to keep the vines strong and vigorous.—(F. B. 231.)

Leaf-Blight.—*Alternaria brassicæ,* var. *nigrescens,* is the usual cause of leaf-blight of musk-melons or cantaloupes throughout the country, though downy mildew and anthracnose also occur and sometimes are associated with the leaf-blight.

Leaf-blight begins in small, round spots, which usually show faint concentric rings. These spots enlarge and their effect is very quickly visible on the leaf. The cantaloupe leaf in particular, owing to its thin and delicate structure, will curl at the margins and shrivel up in a few days.

The disease is caused by a fungus closely related to the species causing early blight of potato, leaf-blight of cabbage, etc. Leaf-blight is spread by spores borne on the upper side of the leaves and carried by the wind and other usual agents. No perfect stage has been discovered, but it is probable that the fungus lives over winter in the fields, and the experience of farmers indicates that it is worse on fields repeatedly planted in melons. Rotation of crops is therefore advisable to lessen its ravages. This disease does not, as a rule, develop in the field as rapidly as the downy mildew, but in warm, humid weather it spreads quickly and does great harm. The ripening of the melons is hastened, their quality greatly injured, and the total crop diminished.

Anthracnose.—This occurs on the leaves and stems of cucumbers and muskmelons, and on the leaves, stems, and fruits of watermelons. It also attacks other cucurbits. It is common and sometimes injurious, but is relatively of less importance than the downy mildew or the leaf-blight.

Circular dead spots from one-fourth to one-half inch in diameter are formed on the leaves. They are distinguishable from the angular spots of the downy mildew, except when the latter have grown very slowly. On the stems anthracnose causes elongated, discolored, and shrunken areas, which finally lead to the death of the branch. Watermelon fruits are often badly spotted by this disease, and much injury is done to the vines.

Anthracnose is due to the fungus *Colletotrichum lagenarium,* which is related to the fungi causing anthracnose in grapes, raspberries, cotton, and beans, and the bitter rot of the apple. It is spread freely by the conidiospores which are produced in abundance in the spots on the leaves and fruit. A perfect form is not known, but the field evidence indicates that the disease persists in the dead vines or elsewhere in old fields, and the destruction of such vines, together with rotation of crops, is recommended as a means of prevention.

Other Leaf-Spot Diseases.—The three fungi previously mentioned are the most common and injurious cucurbit pests, but several minor troubles occur and cause slight losses, which could be prevented by spraying. They hardly require separate mention in a publication of this character, as it would be difficult for the practical grower to distinguish them. The fungi causing them are *Phyllostica cucurbitacearum, Cladosporium cucumerinum, Acremonium* sp., and *Cercospora citrullina.* The powdery mildew of the cucumber, *Erysiphe polygoni,* is common in greenhouses, but infrequent outdoors. It forms a powdery white coating on the leaves without causing a spot, and is thus easily distinguished from the downy mildew.

Other troubles encountered in the field and greenhouse are stigmonose, due to an attack of aphides; wilt and leaf-curl, due to overfertilizing, etc., and root-knot, caused by nematodes.

Wilt.—There is a form of wilt sometimes met with in greenhouses which is due to overfertilizing. Another distinct cucurbit disease is prevalent in the North and West, and is mentioned to avoid confusion with the leaf-blights already described. When a melon, cucumber, or squash vine suddenly wilts throughout its length and dies without appreciable spotting of the leaves the trouble is usually caused by a species of bacteria, *Bacillus tracheiphilus*, which enters and clogs the water-carrying vessels of the stem. This wilt disease is spread by leaf-eating insects and probably also by soil infection. Rotation of crops is advised, together with the addition of an insecticide like Paris green to the Bordeaux mixture. The Bordeaux mixture itself acts as a repellant to the insects and helps to check the spread of wilt. There is experimental evidence showing the value of spraying for wilt, but it should not be expected that this disease will be as fully controlled in this way as the leaf-blights. It is also important to pull and burn diseased vines as soon as they begin to wilt, in order to lessen the spread of the disease.

It should be emphasized that success in spraying for mildews, wilts, etc., is a question of methods. Success is almost wholly dependent upon intelligent oversight, suitable apparatus and thorough application of solutions having the right strength. Since adequate apparatus must be available before spraying can be practiced, its selection is all-important. A poor sprayer and poor methods are costly and extravagant at any price.

Disease Resistance.—The possibility of securing strains or varieties of cucumbers and melons resistant to the leaf-blight fungi has been considered and some experiments have been made. In connection with experiments recently made at Charleston, S. C., all obtainable varieties of cucumbers and muskmelons were planted and left unsprayed to determine their relative susceptibility. All were attacked, and while differences in degree of infection were noted, all were badly injured. One kind of cucumber, the Japanese climbing variety, was more resistant than the others and remained living after they were dead.—(F. B. 231.)

Wilt (Another Account).—The bacterial wilt of cucurbits is prevalent in the North and West, and is mentioned to avoid confusion with the leaf-blights already described. When a melon, cucumber or squash vine suddenly wilts throughout its length and dies without appreciable spotting of the leaves, the trouble is usually caused by *Bacillus tracheiphilus*, and this enters and clogs the water-carrying vessels of the stem. This wilt disease is spread by leaf-eating insects and probably also by soil infection. Rotation of crops is advised, together with the addition of an insecticide like Paris green to the Bordeaux mixture. The Bordeaux itself acts as a repellant to the insects and helps to check the spread of wilt. There is experimental evidence showing the value of spraying for wilt, but it should not be expected that this disease will be as fully controlled as the leaf-blights. It is also important to pull and burn diseased vines as soon as they begin to wilt to lessen the spread of the disease.

Fusarium Wilt.—Another wilt disease of cucumbers and muskmelons similar in appearance to the above, is due not to bacteria, but to a fungus related to the one causing the watermelon wilt, *Neocosmospora vasinfecta*, var. *nivea*. This has been little studied, but is apparently not of great importance. Spraying will not prevent this form of wilt, and rotation of crops is essential. There is also a form of wilt, sometimes met with in greenhouses, which is due to overfertilizing.—(S. C. E. S. B. 116.)

GOURD DISEASES.

Anthracnose, Downy Mildew, Etc.—Gourds are susceptible to the same fungous diseases as the cucumber. The two most conspicuous are anthracnose and downy mildew. The anthracnose, especially, causes spotting and discoloration on the gourds. This may be arrested if, when the gourds are gathered, they are subjected to treatment with scalding water; otherwise the development of the fungus continues while the disfiguring increases. Field treatment in this case is the same as recommended for like diseases of the cucumber.—(Col. E. S. B. 218.)

LETTUCE DISEASES.

Anthracnose or Leaf Perforation.—It shows upon the lettuce plants as dying of spots in the leaves which break free and drop out. The fungus also produces lesions in the midrib of the leaf. In cases of young leaves the attacks of the fungus causes distortion of the leaf, especially toward the top. Apparently very few plants recover after being once attacked, although one may reasonably keep down this disease in the seed beds and young plants by the use of Bordeaux mixture. For houses once seriously infested, thorough fumigation and soil treatment would probably be profitable. It is not generally distributed.

Downy Mildew.—This is the work of another fungus which belongs to the same class as the downy mildew of the cucumber. It forms yellow spots in the upper leaf surface which appear below as whitened, downy covered areas. Like the downy mildew of cucumbers this one may spread very rapidly under favorable conditions, such as warmth and surface watering in the greenhouse. Keeping water from the foliage by sub-irrigation of the beds has been found very beneficial. Gathering and burning the diseased leaves or plants will usually repay the labor. Particular attention to heat and moisture will usually render spraying unnecessary and it is certainly inadvisable except to eliminate the fungus from the house. Avoid too high temperature or too much moisture on plants.

Rosette or Rhizoctonia.—This is a very troublesome disease of greenhouse lettuce which arises from the accumulation of the sterile fungus (*Rhizoctonia* sp.) in heavily manured soils used for continuous greenhouse culture. Upon the young seedlings the Rosette fungus produces stem lesions and rotting off or damping off of the plants or with larger plants which are later attacked upon the branch roots or rootlets, the restricted root development prevents growth of the plant axis and gives a basal development of normal leaves with a rosette-shortened center of leaves. Where serious, the crop is shortened very much and the loss of stand on smaller plants is frequently very heavy. Good results in prevention have been obtained, both from steaming and from formalin drench as per directions in seed and soil treatments. The fungus also attacks the succeeding crops of tomatoes, cucumbers, etc. Attention must in all cases first be given to growing healthy seedling plants, to be followed by soil disinfection.

Lettuce Rot or Lettuce Drop.—This is by all odds the most troublesome disease to the lettuce grower. The plants may rot off at the surface of the earth and the central parts, especially of head lettuce, may become attacked by the rot fungus (*Sclerotinia Libertiana*). The fungus appears as a whitened covering with a liberal production of spores in clusters. At this station it has not been possible to succeed with the head lettuce because of the rot. Fumigation of house, the use of fresh or steamed earth each year and the careful regulation of temperature and water supply, seem to be the measures most favorable to prevention. A low night temperature, less than 50 degrees F. is very desirable, while too high a temperature will usually result in disease. Ventilation is all essential during the day. It is desirable also to gather and burn rotted leaves and plants.

Leaf-Spot.—The leaf-spot fungus (*Septoria consimilis*) is frequent upon wild lettuce plants and occasionally upon outdoor lettuce, especially in late seasons. The small characteristic leaf-spots are not difficult to distinguish from anthracnose. The remedies are confined to avoidance.

Root-Rot and Stem-Rot.—A bacterial stem-blight has been described from Vermont, but has not been found with us. A recent stem-rot infection closely resembles rosette in the behavior and form of affected plants. Microscopic examination shows that the stem tissues are somewhat brown and that the brown and dead rootlets are occupied by the fungus which is referred to a species of Fusarium. This disease is at present under investigation and should be controlled, if at all, by the thorough soil treatments recommended under lettuce rosette. It will be no use to disinfect the houses and then grow plants in diseased soil.

Tip-burn.—Tip-burn of lettuce leaves is often brought to notice. Usually it is associated with unsatisfactory watering in the greenhouse, or with extreme changes to summer weather. The remedy consists in the methods of watering employed.—(Ohio E. S. B. 214.)

ONION DISEASES.

Onion Blight.—How to recognize the disease upon its first appearance is one of the important things for the grower. After the fungus has spread over the entire field and the onion tops are dead or dying, it is no difficult matter for anyone to see that something is wrong. The rapidity with which the disease spreads demands that there be some sign by which we may discover the disease in its earliest stages and so be better enabled to cope with it. Unless the crop of the previous year had been badly infested the fungus first appears on a few onions in one or more parts of the field. The first "muggy" weather of July or late June should be the signal for a general looking over of the fields to discover any infected plants. The examination is best made in the early morning while the dew is still on the onions. A diseased leaf is then easily discernible at a considerable distance. Parts of it will appear of a peculiar violet tint, due to the furry covering of the fruiting parts of the fungus. These will stand out very abundantly and plainly on account of the moisture. Later in the day the parts are more or less collapsed by the drying of sun and wind, and the diseased leaf is more difficult to see. Aside from this peculiar furry violet appearance, the affected leaf is at first like the healthy ones about it. By the second day it has begun to lose its bright color, being paler or even yellowish in spots, where the disease first started. It will now be moldy or furry throughout most of its length and by the third or fourth day collapsed and broken over. The fungus usually appears first on one side of the leaf about midway between its tip and base, from which it spreads rapidly through the entire leaf. Unless the weather is especially favorable the disease will not spread over the field rapidly, but areas several feet in extent will first be evident, here and there through the patch about the places which were first attacked. After several days the affected onions begin slowly to recover. New leaves appear. These replace the affected ones which are drying up. If weather conditions are favorable to the onions this new growth is rapid and often in a week the field appears almost as thrifty as ever. The affected leaves have quite dried up and disappeared while the new growth is erect and green.

Treatment will be found to be most successfully accomplished by systematic spraying, beginning the latter part of June or the first of July, and continuing throughout the season. This has been used very successfully by onion growers in Europe.

Two things are always to be insisted upon in applying the spray: 1st, thoroughness; every side of the leaf must be covered. 2d, force; the mixture must be applied with sufficient force to make it stick to the smooth surface of the onion leaves. A nozzle that gives a fine spray should be used. The Bordeaux used was mixed in the proportion of four pounds of lime and six pounds of blue vitriol (copper sulfate) to a barrel of water. It was found that in some cases this seemed to burn the leaves. A larger proportion of lime would very likely obviate this trouble. A reduction of the strength of the solution has also been recommended.

Location and drainage have much to do with controlling the blight. Properly drained lands are less liable to the disease than wet ones. All barriers, such as tall weeds along ditches or the sides of the field should be removed so as to admit the air freely to the growing onions, thus assuring the rapid evaporation of dews and rains. Lands for onion fields should be chosen in places as much exposed as possible. Swamps surrounded by high hills are especially unfavorable.

We have now considered the means of attacking the fungus in the summer stage. There remains to be considered the winter stage. Since the summer stage which is the destructive one, perishes with the approach of winter, it is evident that if the resting spores by which the parasite manages to pass the winter could be destroyed the disease could not reappear the following season. These spores, as we shall see, pass the winter in the dead leaves of the onion.

These leaves are usually left on the field. Even where they are most carefully raked up and burned large numbers of oospores must still remain in small broken pieces of leaves which cannot be removed. The raking and burning of the tops is to be strongly recommended, as in this way a large part of the resting spores are destroyed. The practice of throwing tops and decaying bulbs back on the field or on manure piles cannot be too strongly condemned.—(N. Y. [Cornell] E. S. B. 218.)

Fusarium Blight.—This is often serious on young onions in old soil and is the forerunner of heavy losses from soft rot in storage.

Downy Mildew (*Peronospora Schleideniana*).—This is likely to occur upon onions, although it has not been seen in Ohio by the writer. The treatment would be as for downy mildew of other plants.

Dry or Black Neck-Rot.—This is the most serious disease of white onions in Ohio since the losses are so very large from it, particularly in Hardin County. The white onions are grown for somewhat special markets and it is the custom, at present, to gather early before the tops fall over, to top at once, and put up in crates in order to preserve the white color of the onion. As a rule this is not practiced with black, red and yellow sorts, so that this neck or dry-rot is not so common with them. Preliminary investigations have been made of this trouble and it appears to be clearly different from the smudge fungus which also disfigures the exterior of white onions. The fungus of dry-rot or black-neck (*Sclerotium cepivorum*) requires further investigation. In Ohio onion districts the losses are very serious between the gathering of the white onions and time for winter storage while the crates are piled in buildings or in covered ricks in fields.

It appears at this time that the early topping of the white onions, leaving a green neck, offers an inviting way for the disease to enter; that the invasion in this direction appears from the sclerotia of the fungus which forms in this region. The disease appears to grow worse with continuous cropping of onions and the losses have recently been so large in storage as to render storage of white onions unprofitable. It has been suggested by this department that the white onions should be gathered and ricked in crates at once, either in buildings or covered with tent or temporary enclosure of building paper and disinfected or treated with formaldehyde gas as per the spray calendar. (See formula elsewhere.) The enclosure should not be opened for 24 to 48 hours after treatment. In this manner it is hoped to keep down the infection of the white onions as well as of any others from similar troubles.

Heart-Rot.—This disease has been under investigation and appears to come in all varieties of onions, following the topping, by its rapid invasion of the center of the bulb through bacterial infection. It should be controlled by attention to disinfection of the topping machine or to similar treatment to that recommended for dry-rot. This disease ends in the complete destruction of the bulbs through a soft rot different from that described under soft-rot.

Smudge.—This fungus (*Vermicularia circinans*) develops as a superficial spotting upon the exterior, especially attacking the white varieties; it is really an anthracnose of onions. For some time, because of its coincident development with the black neck or dry-rot, these two troubles have been confused. It is now apparently clear that there is no connection between the two, although this fungus causes dry rotting of sets and bulbs. The smudge fungus is cumulatively worse on old land where onions are grown consecutively. Apparently also in addition to rotation of crops the formalin drip treatment described under smut gives good results in keeping down this fungus. In field experiments made heretofore, the onions have been lost in storage from the dry-rot and the smudge disease has not been studied very fully in storage; apart from this it is believed to have little or no connection with the commoner storage rots, although the disfiguring effects of badly spotted onions reduce their market value, and rotting does take place as a result of it. The illustrations give characteristic appearances of these compared with healthy onions.—(Ohio E. S. B. 214.)

Onion Smut.—The presence of smut in seedling onions is first indicated by one or more dark spots at various points in the leaves of the onion; these spots, especially when viewed by holding them between the observer and the light, exhibit a dark, opaque character in marked contrast with the remainder of the leaf. As growth proceeds these affected leaves die above while the dark spots are exposed as sooty, powdery masses by the decay of the surrounding leaves. All stages of disease from smut may be observed if one studies the seedling when in the field. Some die soon after infection, others survive for a longer time, while yet others continue to live despite the attack of the smut, and though showing many evidences of smut, survive until the time for harvesting the crop is reached. Doubtless other conditions than the fact of infection, such as lack of sufficient moisture, will cause earlier death and, conversely, abundant moisture may increase the resistance of the onion plant, largely by increasing its vigor and power of resistance. When onion seedlings survive for some time the smut will be found upon or within the bulb; either affecting the external layers, or attacking the inner layers, where its presence is scarcely obvious from without. The tendency of such smutted onions is to rot or dry up so that they are readily separated from the healthy ones. This is particularly true in the handling of onion sets and this fact greatly facilitates the separation of diseased sets.—(Ohio E. S. B. 122.)

Suggestions for Preventing Onion Smut.—The suggestions arising from the brief study made of this subject relate to general field handling of sets and to the treatment of seed; in both cases the object is to reduce and prevent smut. Under the first heading every method should be employed to reduce or destroy smut spores. To this end it would appear practicable to collect all refuse from the screening of the sets, either in shallow boxes or upon canvas and give these a baptism of fire sufficient to destroy the spores. This material, including tops, smutted sets and infected earth, would be greatly improved in this respect by burning. Under the head of treatments to be applied in planting, formalin and stone lime are both promising, if the present season's results are found capable of repetition on a large scale. It would seem possible to increase the percentage of formaldehyde, of forty per cent strength, or formalin such as herein mentioned, to one-half per cent solution, or 1 pound to 25 gallons of water, or 1 ounce to 1½ gallons. Upon this point I would advise the use rather of a three-eighths per cent solution, 1 ounce to 2 gallons of water, for all save smaller experimentation until the safety of a greater strength is established, likewise its greater efficiency, which can now only be inferred.

It seems necessary to apply the formalin solution in some manner as that before described, although there should be nothing incompatible with hand carts, sleds and the like in devices for making the rows and sprinkling the solution. Horse implements can scarcely be used at these stages because of the effect of trampling. A barrel containing the solution and mounted upon a cart should prove a means of easily applying the formalin by rose (sprinkler) suitably connected. In the application of lime the usual methods of applying by spreading stone lime before slaking, or better, the ground burnt lime, should prove sufficient. It does not seem probable that more than one hundred and fifty bushels per acre will be required and a less amount may prove equally effective. Where set growers have smut infected land to plant it is advised to use lime on one strip; formalin on another, and both together on yet another of equal area, alternating with at least two untreated strips of equal size to test field results.

Summary.—This onion smut infests the soil into which it has become introduced and attacks onions growing from seed in such soil. It does not attack sound sets or mother onions. The onion smut is not introduced into onion seed if properly handled, but much more probably in onion sets or infected onions. It may be spread in a variety of ways. Preventive treatment and measures of avoidance seem necessary to preserve the onion set industry from abandonment in parts of one district. The treatment measures indicated by the preliminary experiments recorded in this bulletin consist in the application of *stone lime* and in the use of forty per cent formaldehyde commercially known as *formalin*.—(Ohio E. S. B. 122.)

To apply formalin use at a rate of 1 pound formalin to 37½ to 50 gallons of water (1 oz. to 2 or 3 gallons) and apply with sprinkler upon the scattered seeds until well moistened, then cover with earth promptly.

Apply stone lime after the usual methods, spreading before permitting it to slake, either in the usual form or finely ground soon before seeding upon the prepared land. Harrowing may follow, and immediately precede the seeding of this land. Ground lime admits of easier application without increase of cost.—(Ohio E. S. B. 122.)

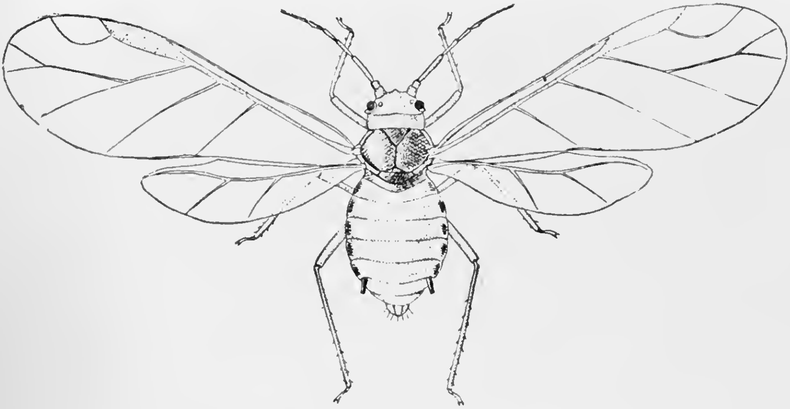
PEA DISEASES.

Pea Blight.—A close examination of the diseased plants showed that the stems had been attacked at many points, frequently as high as one and one-half feet from the ground, though most severely *near* the ground where the disease starts. In the beginning, dead areas were formed on the stem in the shape of oval or elongated lesions. At a point from the top of the ground to two or three inches above ground, these lesions were so numerous and had spread so rapidly, as to become continuous, leaving the stem encircled by a dead area. In some cases, the woody part of the stem was also dead, though the greater number of such plants still remained green above. On the leaves were orbicular or oval dead spots, one-eighth to one-half inch in diameter. These areas are darker at the circumference. Below, the leaves were badly spotted, causing them to die. In the green-house experiments, the spotting of leaves failed to develop to any extent, though the attack at germination, and later, at the base of the stem, was more severe than out of doors. In such indoor grown plants, the dead areas at the base do not often extend much above the surface. The base of the stem is dead and shrunken as is usual when attacked below the ground. A little higher up (even with the first leaf) may be seen the ordinary lesion due to the fungus. The growing tip is also often attacked. This is frequently the case where no trace of the disease occurs below. The injury to the original sprout or stem will cause one or more secondary shoots to appear. This explains many cases of the so-called freak peas. If the injury to the tip be on larger plants, a side branch may be developed prematurely and become the leading shoot.

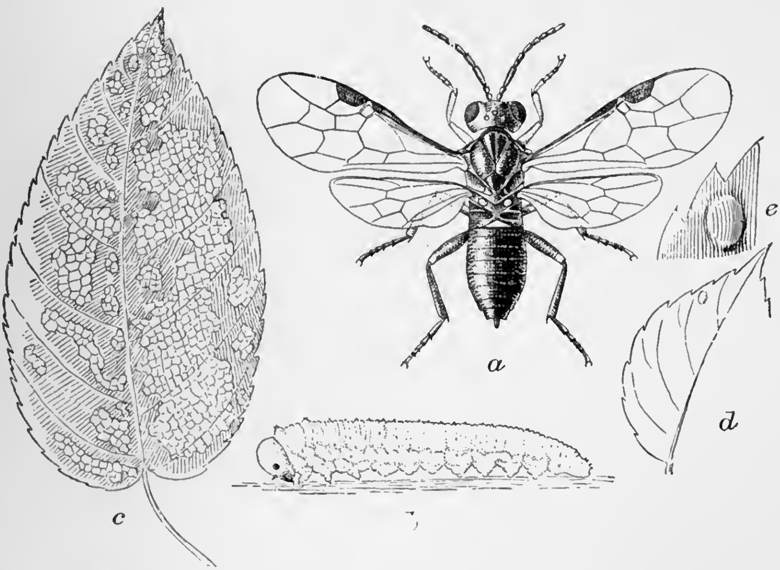
These effects do not always result from Ascochyta alone, for *any* severe injury to the stem may cause the growth of secondary shoots. Such plants as are not killed by the fungus before the time of flowering, develop pods in proportion to their vigor. The pods usually become badly attacked and exhibit spots.—(Ohio E. S. B. 173.)

Perhaps the most important thing in connection with the life history of the fungus is, that the vegetative part of mycelium, infecting these spots of the pods, grows through the husk into the seed. Frequently it grows entirely through the pod, forming similar spots on both sides. When the fungus grows into the seed, brown spots may be formed on the surface. In the worst cases, half the surface is frequently discolored and the seed adheres to the pod. These areas are much more striking on green colored peas, such as the Market Garden variety, than on the yellowish varieties, such as the Admiral. Pea seed may be badly affected with this fungus and yet escape ordinary observation, as only the most badly diseased ones will show serious spots. When the pea is exposed for a few days to considerable moisture, then spots appear.

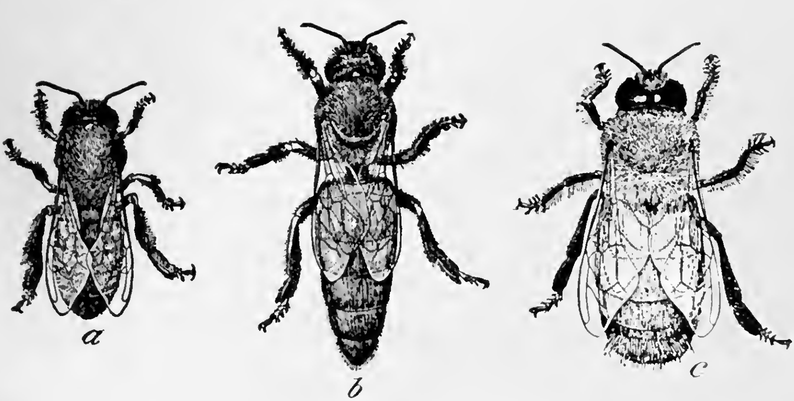
Recommendations.—The germination of such diseased seed is very poor. Of those selected as being very badly affected, only 6 per cent germinated. It has been previously demonstrated that the fungus passes over to the young plant from the seed. The severity of the attack may vary very much, even when such seeds do germi-



Corn Leaf-Aphis: Winged Female Enlarged. Dept. of Agr.



American Rose-Slug in Various Stages. Dept. of Agr. (See page 273.)



The Honey Bee. *A.* Worker. *B.* Queen. *C.* Drone. Twice Natural Size.
Dept. of Agr.

(See pages 401-424.)

nate. Plants of equal age may range in height from two inches to two feet.

Seed treatment by immersion in liquid fungicides failed to produce good results, as the fungus within the seed is less susceptible than the pea germ. Heating the seed failed for a similar reason. Rolling the seed in Bordeaux dust increased the per cent of germination slightly. Tying up the vines and spraying, while increasing the crop only slightly, produced peas much freer from this and other fungi and is of much value in growing healthy seed peas. Spraying in this manner should prove a commercial success in growing seed peas. Planting such healthy peas in soil free from the fungus is recommended as the best means of reducing the loss from blight.

This blight fungus is known to attack alfalfa, chick pea, common bean and hairy vetch. All the varieties of the common pea examined this year were affected; but some varieties much more than others.—(Ohio E. S. B. 173.)

Powdery Mildew of the Pea.—The powdery mildew fungus (*Erysiphe communis*) is exceedingly common on beans, clover, lupines, peas and other members of the family to which the pea belongs, as well as on very many other hosts. It is ordinarily recognized by the whitish or grayish coating on all parts of the pea plant, especially late in the season. The loss from this mildew during the past season was quite large.

The mildew fungus likewise lives over winter on the seed. On account of its habits it is easily prevented by applications of Bordeaux mixture. Unlike the blight fungus, Ascochyta, the vegetative part of the mildew fungus grows mostly on the exterior of the host plant. Hence, the fungicide is not only a preventive, but actually kills the fungus in great part, when sprayed upon it. On account of this manner of growing, many of the powdery mildews are controlled by the use of sulphur alone—applications of which have but little if any effect on most other parasitic fungi. The sprayed late crop of 1905 showed not a trace of mildew; while the unsprayed late crop was entirely covered. So bad was the attack, that many plants failed to mature good seed. This is, in part, responsible for the very low per cent of germination of peas from the unsprayed vines.

POTATO DISEASES.

Blackleg or Black-Stem Disease of the Potato.—This is a bacterial disease which attacks both the stem and tuber of the Irish potato. Various investigators, mostly in Europe, have isolated from the diseased plants and described under different names bacteria which were again capable of causing very similar effects upon the host upon inoculation. Hence so far as our present knowledge goes blackleg, strictly speaking, is a general term applied to a type of bacterial disease which attacks and destroys the base of the potato stem, producing a characteristic blackening of the diseased tissues, rather than a term applied to a single disease caused by a specific organism. However, the organisms are so near alike and are so nearly identical in their effects upon the host that so far as the practical agriculturalist alone is concerned the distinctions made are, in the opinion of the writer, of little consequence. Preventive measures which are effective with one under Maine climatic conditions would be, in all probability, equally applicable to all. Blackleg is not the same as the Southern bacterial disease of the potato stem and tuber caused by *B. solanacearum* Smith.

Both stems and tubers are attacked. The diseased plants first appear more or less unthrifty and usually undersized. The branches and leaves, instead of spreading out normally, tend to grow upward, forming a more or less compact top, frequently with the young leaves curled and folded up along the mid-rib. Later they become lighter green or even yellow and the whole plant gradually dies. If the disease progresses rapidly the plants may fall over suddenly and wilt with very little previous signs of disease. The same general symptoms may be produced by certain other stem diseases, or even mechanical or insect injuries of the stem at or below the surface of the ground.

The appearance of the diseased stems at once differentiates blackleg from other described potato diseases. Stems so attacked are characterized by an inky-black discoloration extending from the base of the stem, where it attaches to the seed piece, up sometimes one, two or even three inches above the surface of the ground. Under favorable weather conditions the disease may, in exceptional cases, follow up the stem for several inches, or even out on the larger branches. The seed pieces from which the diseased plants spring are invariably decayed, and young tubers which have been formed before the destruction of the stem may sometimes be attacked by a soft rot caused by the bacteria being conveyed to them along the underground branches of the stem upon which they are produced.

The disease is carried over from year to year by the organisms living in decaying, bruised, cracked or otherwise imperfect seed potatoes. They are readily killed by drying and are probably incapable of existing in a living state on the surfaces of dry, sound potato tubers. Under ordinary conditions blackleg has not been observed in Maine to spread from hill to hill in the field and, as will be shown later, there is quite conclusive evidence that the germs do not live over winter in the soil under the climatic conditions which exist in this State.—(Me. E. S. B. 194.)

Eliminating Blackleg from Seed Potatoes.—From the foregoing discussion it is evident that if seed potatoes are carefully selected so that only those which are absolutely sound and perfect are used for seed purposes and these treated with formaldehyde that the disease can be eliminated in from one to two years' time.

For home use it is strongly recommended that only formaldehyde solution be employed. This consists of one pint of 40 per cent formaldehyde in 30 gallons of water in which the potatoes should be soaked 2 hours and then spread out on a clean place to dry, preferably in the sun. Exposure to sunlight will also assist in destroying the bacteria causing the disease and tend to hasten germination.

It is only advised that the formaldehyde gas method be used by the large seed dealers who must pick up a considerable amount of their stock under conditions which preclude a knowledge of the amount of disease which appeared on the fields where the stock was grown. In such cases a special disinfecting room should be provided and fitted up with provisions made for the proper regulation of the temperature and moisture conditions during treatment. This work should be placed in the hands of a competent man who thoroughly understands each step and detail of the process. All seed tubers which are not known to be free from the germs of blackleg and potato scab should be disinfected in this way before being shipped.—(Me. E. S. B. 194.)

Early Blight of Potato.—It may be readily recognized and easily distinguished from the Late Blight and the other potato diseases. Early Blight begins to show itself about the time that the blossoms appear. More rarely it attacks plants scarcely six inches high. The first indications are relatively small grayish-brown spots, which, as they become larger, are marked with faint concentric circles, giving a target-like appearance to them. The spots may increase in size till several of them run together and form large patches of dead tissue. In the course of a few days these spots become brown and withered, while the rest of the leaf takes on a yellowish, sickly color, though the stems may remain green. Sometimes the disease progresses quite slowly and the vitality of the plant is only gradually reduced. In any case, however, the tubers either stop growing entirely or remain so small as to make them of little value. The death of the vines in this way is often mistaken for early ripening and it then occasions a surprise to find that no tubers of value are present.

Any injury to the foliage, such as insect bites or bruises from hail, seems to furnish the condition for the entrance of the fungus into the leaf. Likewise any decline in the vigor of the plant seems to invite attack. Drought, poor soil, delayed development due to cold weather, excessive heat tending towards wilting or sun-scald, all make the plants less able to withstand the attacks of this blight. In other words, the more nearly perfect the plant and the more vigorous its growth the less likely it is to suffer from this parasite.—(Wyo. E. S. B. 71.)

Satisfactory treatment for this disease has not yet been found. Many experiments, however, have shown that the effects of the disease may be greatly reduced by two or three thorough sprayings with Bordeaux mixture. The spraying must be thoroughly done and the first application must be made previous to the appearance of the blight. After the leaves have become filled with the mycelium and the spots are beginning to show it is too late. Prevention must be the aim, and this is accomplished by putting the leaves in such a condition by the application of the Bordeaux that the spores cannot germinate upon the leaf surface. For further directions, see the subject of spraying at the close of this bulletin.

Late Blight of Potato.—During the time that the fungus is spreading its mycelium through the tissues of the leaf there is little to indicate its presence. When the fruiting stage is reached it soon becomes evident enough by the formation of brown spots, which grow gradually larger and larger, finally turning black and a little later decomposing and emitting a disagreeable but characteristic odor. If one of these infested areas be examined closely, it will be found to be bordered by a grayish-white mildew.

For the development of the mycelium, that is, for the growth of the fungus within the potato plant, moderately cool weather seems the most favorable. For this reason this disease rarely proves troublesome where high temperatures prevail for considerable periods of time. Spore production, however, seems to be hastened and enormously increased when a few days of warm, cloudy and muggy weather alternate with the longer cooler periods. Under such conditions, a field showing but slight infection, may in a few days look as if it had been swept by fire or frost. It rarely attacks early potatoes, mostly appearing upon the late varieties during the tuber-forming period.

Various experiment station workers have tried different remedies for holding this disease in check. At some stations these experiments have been carried on for many years. While several have given results which were of value, no treatment has been uniformly successful as the application of Bordeaux mixture. The universal experience is that spraying with this fluid will so nearly control the late blight as to make it possible to secure a crop even in those years when this disease is most prevalent. It requires, however, that the spraying should be begun in time and continued at intervals throughout the growing season. As already stated, it must be a precautionary measure. If not begun until after the blight is evident in the field only partial control can be expected. If the spray is applied thoroughly from the beginning, not only will the blight be controlled, but the rot of the crop which usually follows a severe attack is altogether prevented.—(Wyo. E. B. B. 71.)

Fusarium Disease of Potatoes.—On badly infected soils the disease is characterized as follows: The stand is uneven, though few of the hills are missing. The early growth is somewhat slow. When the plants reach a height of 10 to 14 inches, there is an apparent cessation of growth. The first indication of the disease is usually conspicuous at this time. The preliminary symptoms are a light green color of the foliage, particularly the lower leaves; this is accompanied during the heat of the day by a partial wilting and an inward and upward rolling of the upper leaves. The color gradually changes to a sickly yellow, which slowly and evenly covers the affected vines. The wilting and rolling of the leaves extends to all parts of the affected plants. In the varieties with heavy dark-green foliage the wilting and rolling-in symptoms are not always accompanied by marked changes in the leaf coloration.

As the disease progresses the field takes on a mottled yellow to light green color. The growth of the foliage is greatly restricted. The wilting becomes more pronounced; there is associated much tipburn owing to the failure of the leaflets to fully recover at night from the severe wilt of the mid-day. The lower leaves of the affected plants are first to die; they fall into a vertical position along side the stem, hanging by only a small part of the bark below. The upper leaves usually do not drop, but droop over upon wilting. Occasional hills will show only one or two vines afflicted. Plants which early succumb to the disease pull up easily, manifesting a badly rotted condition of the root. As a rule, the blighted stems do not fall, but remain quite erect except for the drooping top.

A careful examination of the underground parts of the afflicted plants in their early symptoms reveals a number of pathological conditions. When the soil is thoroughly sick many of the root hairs and smaller secondary roots are entirely destroyed. Parts of the main root and many of the larger secondary roots manifest a vitreous, sickly, watery, aspect, instead of the clear white of healthy roots. Cross sections of the large roots and the stem at a level with the ground or below show some or all of the vessels to be of a brown or dull gray discoloration. Following the marked yellowing of the fields a premature ripening or dying of the plants sets in. The life of the crop is shortened fully three to six weeks. The tubers are undersized and the yield is materially reduced.

The subtle and persistent nature of the disease is such as to mislead even the plant pathologist. The progress of the disease is greater in certain areas than in others, due probably to several different factors, such as previous infection being uneven, irregular drainage, different soil conditions, etc.

The Disease a Root Infection.—The disease makes its attack by way of the root system. Nearly all such root infecting parasites are more or less persistent soil organisms. We have in this fusarium of potato blight no exception to this rule.

The growth of foliage put out by plants is determined wholly by the extent of the root system. When the root hairs and smaller secondary roots are destroyed by a fungus disease the plant adjusts itself to these conditions by a cessation of the foliage growth, and attempts to recover itself by putting out an additional root growth. However, with this particular fungus, it is not restricted to an attack of the root hairs or secondary roots, but it readily penetrates the main root, killing the cambium and blocking up the water conducting vessels. Artificial culture work upon the roots of sick plants showed them to be abundantly infected with the parasitic fungus. The root hairs and secondary roots were badly destroyed. It is this crippling and destruction of the root system that brings about the rapid premature dying of the crop. The stems above the ground show little or no indication of the fungus until the plant has nearly succumbed to the disease. Later, however, the fungus may produce a copious growth of spores for a considerable distance up the wilted stem.

The infection of the new crop takes place directly following the dying of the root system. The fungus penetrates the tuber-bearing stems and follows these into the tuber. After a short penetration of the new potato the work of the fungus takes place much more slowly. Usually at digging time the depth of penetration seldom reaches deeper than one-fourth to one-half inch. In some of the more susceptible varieties, however, the stem end may be rotted to a depth of one inch or more.

The Disease an Internal Infection of the Tuber.—With this internal infection of the new crop we have come to one of the most important facts regarding the disease. The depth of infection varies from that of a very shallow, light yellowing of the vessels at the stem end, so inconspicuous as to be entirely passed over by the layman, to that of a pronounced blackening of the vessels to a depth of one-half inch, or indeed later it may extend clear through the tuber. When the infection is very light the presence of the parasitic fungus can be determined only by microscopic examination, or preferably by means of artificial cultures. This internal infection may be very marked and yet in no way impair the superficial appearance of the tubers, nor even in keeping qualities when the potatoes are placed in proper storage. Indeed, it is this inactive or dormant internal infection during storage which is the means of bringing about the widespread distribution of the disease. Under improper storage much of this infection becomes so active as to cause a high percentage of dry-rot, an extreme condition in which the potatoes are of no value for food or seed. The importance to the grower of being able to recognize this internal infection cannot be over-emphasized. With the seed lies the only possible opportunity of controlling the dissemination of the disease. The appearance of this infection in the tubers varies slightly in different varieties. As a rule the ring of vessels becomes deeply blackened wherever the fungus penetrates. Sometimes, however, the fungus is not confined strictly to the vessels, but may penetrate at random throughout the flesh of the tuber. This peppered appearance was noted in several of the early varieties and was identified as the same disease by means of artificial cultures.

A Cause of Dry-Rot in Storage.—Since the recognition of the fusarium as a cause of blight in the field, and of an internal infection of the tubers, pathologists have lost no time in learning of the progress of this internal infection in storage. As a dry rot the disease makes its greatest headway under high temperatures in the presence of considerable moisture. For these reasons the storage of potatoes in warm cellars under dwellings is a practice certainly not to be recommended. The writer carried out experiments on the progress of the disease with selection, as one picker can gather 30 to 40 per cent of the hills for seed purposes while the other gathers the remainder. The wagon box may be divided to accommodate the two divisions. Immediately upon drying the potatoes selected for seed should be placed in the best available storage.

Treatment Previous to Planting.—Previous to seed treatment, the tubers should be inspected and if the seed is carrying a shallow infection, this should be cut away. This can be done without injuring in the least the potatoes for seed purposes.

There are two satisfactory methods of treating seed potatoes. The older method is carried out by placing the seed in a solution made by using one pound of formaldehyde (40 per cent grade) in 30 gallons of water. The seed remains in this solution one and one-half to two hours. It is then removed and allowed to dry. A longer treatment than two hours will injure the seed. A treatment of one-half is sufficient when the seed is not carrying scab or the fungus of the rosette disease.

The easier treatment, also the most rapid, is the formaldehyde gas method. It requires a room that may be made reasonably tight by blocking cracks and knot holes. This method is given in the Ohio Station Bulletins 199 and 214, from which the writer will quote the formula and operations.

FORMALDEHYDE GAS.

Commercial 40 per cent formaldehyde......... 3 pounds
Potassium permanganate ....23 ounces

Sufficient for 1000 cu. ft. of space occupied by crates or trays.

Enclose open tiers or piles of slat crates filled with dry onions, potatoes, etc., in tight room or oiled tent or canvas buried in the earth about the base. Generate the formaldehyde gas in a flat bottomed dish or pan of adequate capacity by placing one of the materials, as the liquid formaldehyde, in the pan, and adding the other the last thing before retiring. Then close tight and allow to remain closed 24 to 48 hours.

Proportionate or multiple unit amounts may be taken for smaller or larger enclosed spaces. Applicable to fumigation of seed potatoes for scab, sweet potatoes for rot troubles and to newly gathered, dry onions before storing for winter.—(Ohio E. S. B. 229.)

Potato Scab.—The disease first shows itself as a minute reddish or brownish spot on the surface of the tuber. The infested area becomes more extended forming a scab-like crust which may become cracked and furrowed. Freshly dug, infested potatoes exhibit a very fine, grayish mould which disappears upon exposure to the air. This mould-like appearing matter constitutes the spore-producing portion of the fungus, which Dr. Thaxter named *Oospora scabies.*—(Nevada E. S. B. 26.)

Preventive Measures for Scab.—The most frequent source of infection lies in the seed planted, and the experience of eastern growers has been that by disinfecting the seed and by planting in land free from scab a clean crop may be produced. It is therefore of the greatest importance that those California growers who have land not already infected by this disease should seek to keep it healthy by allowing nothing but disinfected seed to be planted.

In the majority of cases, however, it is necessary to deal with land that has already been infected by the cultivation of one or more potato crops. The disease has already been introduced; the problem is, how to control it. It goes without saying that additional reinfection should be avoided by disinfecting all the seed planted, in accordance with directions given later. Additional means to be adopted comprise rotation of crops and soil treatment.

Scab tends to diminish when land is planted in crops which do not harbor the parasite. Other root crops, however, such as sugar beets, turnips, etc., must be avoided. The length of time required to free land from scab varies in different sections, but, as a rule, a period of three years will very greatly reduce the amount of disease, though it may not be entirely exterminated after five, or even ten, years.

The principal point to be kept in mind in choosing rotation crops is to increase the amount of organic acids in the soil by plowing under green crops, such as rye, clover, vetch, etc., which by their decay tend to produce an acid reaction in the soil. It is possible that the soil can be further favorably modified by the use of fertilizers, such as acid phosphate, muriate of potash, land plaster, etc., which leave an acid residue. It seems at first thought illogical to advise plowing under green crops on soils largely made up of organic matter and to suggest fertilizers where there appears to be no lack of plant food. No such positive recommendation is intended, but in the absence of knowledge of the subject such experiments to test this should be undertaken. The beneficial effect of such treatment is well recognized in the Eastern states.

The chemical treatment of the soil to reduce scab promises but little. Applications of sulphur at the rate of 300 pounds per acre have been used with some degree of success in Delaware and New Jersey and might give good results in California.

The most effective method of disinfecting seed potatoes is by the use of formaldehyde gas liberated by mixing the commercial solution with potassium permanganate. This method is adapted to the disinfection of large quantities of potatoes in a short time. To use it, an air-tight shed should be constructed of sufficient size to hold whatever quantity it may be desired to treat at one time. This may be made of rough lumber, lined with building paper and provided with a tight door. The potatoes may be treated in sacks, but these sacks must be piled so as to allow a free circulation of air all around them. It is suggested that they be piled in tiers, with two 2 by 4 inch scantlings between each layer of sacks. Space should be left in the center of the building for placing the charge of formaldehyde, which should be set off in shallow pans, such as galvanized washtubs. For each 1,000 cubic feet 23 ounces of potassium permanganate and 3 pints of formaldehyde should be allowed. After the potatoes are properly stacked and everything is made ready, the permanganate should be spread in a thin layer on the bottom of the pan, the required quantity of formaldehyde poured in and stirred quickly, and the building vacated. The building should then be kept closed tight for twenty-four hours, when it may be opened and the potatoes taken out.

Formaldehyde is a nonpoisonous but highly irritant fluid which can be purchased in small lots at about 50 cents a pound, in carboy lots at 20 cents, or in barrel lots at about 12 cents. Potassium permanganate is a reddish brown, crystalline substance, purchasable at from 13 to 25 cents a pound.

The precaution should be taken not to pile any potatoes directly over the pans or within 3 feet laterally, as the gas there might be strong enough to injure the potatoes and destroy their germinating power. The formaldehyde works best in a humid atmosphere. It is therefore advised that the floor of the shed be wet down before the treatment is made. The potatoes, however, should not be wet, as the disinfection is more thorough if the surfaces are dry.

Small quantities of potatoes may be disinfected by soaking in a solution of 1 pint of formaldehyde to 30 gallons of water for two hours. Either the gas or the solution treatment may be applied some time previous to planting, provided the potatoes are not exposed to reinfection by being put into receptacles that have previously held scabby potatoes. The treatment should also be made before the potatoes are cut for seed.

Wart Disease of the Potato.—The disease, which has been known as warty disease, black scab, canker, and cauliflower, is one which attacks the tuber principally, and consequently is not observed until harvesting time. In a bad attack of the disease big, dark, warty excrescences, sometimes as large as the tuber itself, appear on its sides or ends. The growth consists here of a mass of coral-like or more or less scabby excrescences or nodules, similar in appearance to the well-known crown or root gall of apples. The adherent earth can be easily washed off when the character of the growth becomes more apparent. It is not spongy and not detachable from the tuber. It is of a somewhat lighter color at the base and dotted with minute rusty-brown spots over the surface. In an advanced stage the tubers are wholly covered by this growth, having lost every resemblance to potatoes. They are lumps of irregular outline, never sypherical or oblong, but simply a mass of ragged and edged excrescences. A still more advanced stage occurs when the fungus has utilized every particle of food stored in the tuber and has reduced it to a brownish-black soft mass giving off a very unpleasant putrefactive odor. This is the most dangerous stage of the disease, and the tubers which have reached it can not be harvested whole. They break in pieces, and thus the brownish, pulpy mass, consisting almost entirely of spores of the fungus and remains of the cell walls of the potato, is broken up, the spores are liberated in millions, and the land is badly infected for years.

In a mild attack the eyes first appear grayish, then turn brown, and finally black, while in a healthy tuber these are whitish or purplish in color. The tuber is only slightly disfigured and its keeping qualities do not seem to be impaired. While the tuber is the part of the plant chiefly affected, infection may take place in all the young tissues of the plant, the roots, stolons, stems, and even the leaves.

Threatening Nature of the Disease.—All reports indicate that the potato wart is one of the most serious of all known diseases of the potato. It converts the tuber into an ugly, irregular, and utterly unsalable growth. When established in a field it may affect the entire crop, and the land remains so infected that potatoes can not be successfully grown for six or more years. When once established in the land it is useless to grow potatoes again until the pest has been starved out or otherwise destroyed; but so far as is known no other crops are liable to be attacked. Quite the worst case seen in Cheshire occurred on land that had not borne potatoes for six years; seed from the same source as that employed on this land yielded satisfactory results elsewhere, indicating that spores were not introduced by the seed, whilst the manure employed started no infection elsewhere. This indicates prolonged vitality on the part of the fungus, which would render starving out a very tedious process.

It is quite clear, however, that the black scab disease threatens to inflict such serious injury on the potato crop as to warrant the Board of Agriculture taking official action. The disease is viewed with alarm by both the scientific and the practical man, and yet no steps are being taken to deal with this pest which, if it is allowed to spread through the country and to reach Ireland, will cause losses of hundreds of thousands of pounds.

Borthwick (1907), referring to an outbreak in Scotland, said that the whole crop was damaged to the extent that they could not be used. They were quite useless, the early varieties being, if anything, worse than the late, especially the early kidneys. The disease was first noticed when the new potatoes began to form. It first appeared on the stems as a greenish-looking canker, which attacked the tubers as they grew and soon made them a mass of corruption.

All infected potatoes should be boiled or burned. No part of any lot containing diseased potatoes should be used for seed purposes. If the disease is found on growing potatoes, heroic measures should be taken to eradicate the trouble by burning the entire lot and planting no more potatoes on that field for six or seven years.—(B. P. I. Cir. 52.)

TOMATO DISEASES.

Leaf Blight of Tomato.—Leaf blight (Septoria) is frequently seen on field crops of tomatoes, but we have not noticed it on crops grown under glass. The trouble has occasionally been observed in this state on greenhouse tomatoes. For field crops spraying has been recommended. In the greenhouse the remedy is more simple, since the disease, according to our observation, results from too much crowding, and is of rare occurrence here.

A similar spot is often found on chrysanthemums. On both tomatoes and chrysanthemums the disease is confined to the lower shaded leaves of closely planted crops, and it has never been observed by us on individual plants of chrysanthemums grown in pots or where light and air have access to the foliage. In the fall and winter, when the light is poor, the lower leaves of crowded plants often deteriorate and show signs of prematurity; consequently becoming more susceptible to disease. To prevent this trouble the crop should not be planted too closely, and the foliage should receive more air and sunlight. On too closely planted tomato plants the lower leaves may be removed, and if diseased, destroyed. The pruning of the lower leaves is not harmful and lets in more light and air where it is needed.—(Mass. Bul. 138.)

Damping Off.—This disease rarely occurs, excepting in the seedbed. It manifests itself by the plants falling over, and looking very much as if they had been gnawed off by some insect. These apparently gnawed-off areas occur at different points in the seedbeds, and the fungus which causes the trouble spreads out from these

Potato Showing Wart Disease. Dept. of Agr.

Resting Spores of Potato Wart Disease. Dept. of Agr.

points in all directions. The disease occurs usually when the plants are covered, as in a cold frame, or when the seedbed is located in a moist hammock. Damping off is specifically caused, for the most part, by one or more fungi which inhabit the soil.

In case the seedbed is located in a moist hammock it should be ditched around so as to draw the water off and dry the bed thoroughly. If the plants are very thick set in the bed it would be best to remove a portion of them so as to let in the sunlight on the ground. In addition to this, a great deal of good can be done by spraying the soil thoroughly with an ammoniacal solution of copper carbonate. Stirring the soil between the seedlings is a further aid towards reducing the loss from these fungi. Seedlings in rows can be easily handled in this way.

Hollow Stem.—This diseased condition of the plants manifests itself in the field shortly after they have been set out. The plants at the time of setting out may look perfectly healthy and normal, but after some days or a week, they begin to fall over, remaining green after they have fallen over, but making no growth. Even the plants that do not fall make only an indifferent growth and many of them do not recover. Those that are so weakened as to fall over almost never recover. On examining such plants the stems will be found to be hollow. Many of the plants that are still standing will also be found to have hollow stems.

The cause of this trouble is that the plants have been grown in a seedbed that has been overfed with nitrogenous material, and which has been given more moisture than is necessary to produce vigorous plants. In short, they are extra forced plants. These conditions frequently arise in years when the seedbeds have been frozen out and the tomato grower wishes to force his plants with all possible speed to get them large enough to set in the field.

The tomato growers suffer less loss than they did a few years ago from this trouble, inasmuch as the majority of them know how to handle the plants in the seedbeds so as to prevent this difficulty. If the plants are growing too luxuriantly to be in the best condition for setting out; that is, if the plants are too tender to stand adverse field conditions, the tomato growers now harden off their plants by withholding a portion of the water from the beds. This must not be done too abruptly, otherwise a large proportion of the plants may be afflicted with hollow stem in the seedbed. If the plants have been thus hardened off for some days or a week, they will be in a condition to plant in the field.—(Fla. E. S. B. 91.)

Other Plants Affected.—While it has not been definitely proved that this bacterium may live in the soil from one tomato season to another in Florida, it is possible, in any case, for this disease to be carried over from one year to another on some of our wild plants which are subject to it. Consequently, a field that has been severely affected by the bacterial blight one year, should not be planted either to tomatoes, Irish potatoes, or eggplants during the succeeding year. In addition to these vegetables, the Jamestown weed, black night-shade, and several weeds of this family (*Solanaceae*), are affected by this bacterium.

In some cases it is rather difficult to distinguish between plants that are affected with the bacterial blight and those that are diseased with the sclerotium blight. Typical cases of each form have many points of similarity. As a general rule, a plant that is suffering from the bacterial blight becomes infected through a leaf. This leaf shows that it is infected by wilting. Next, that portion of the plant to which the leaf is attached begins to wilt; and finally the entire plant will become involved. In the case of the sclerotium blight the whole plant usually shows the distress at once, and does not, as a rule, die off as quickly as a plant attacked by bacterial blight. In the case of bacterial blight a dark gummy substance is apt to be deposited in the woody portion of the stems. Sometimes these dark streaks also grow in the leaf stalks. In this respect the bacterial blight may be confused with the fungous blight. It is not usual for this dark, gummy substance to be deposited in the stems of the plant or in the leaf stalk when the plant is attacked by the sclerotium blight.

These three forms of blight may be easily diagnosed by the plant pathologist with his microscope in the laboratory, but they have so many points of similarity that it is very difficult to describe them in such a way as to enable the tomato grower to distinguish them beyond a question of doubt. The plant pathologist, however, who comes in contact with the three forms of blight regularly has no difficulty in diagnosing them in the field.

Dropping of Bloom Buds.—During some years this trouble occasions a greater loss to the tomato growers than any of the diseases that are caused by micro-organisms. The plant puts out the bloom hands or clusters, but after the blooms have opened they drop off, leaving no fruit set. The plant continues to grow and produce new blooms, but these in turn may be shed. There are a number of causes which bring about this condition.

First among the most general and widespread causes for the dropping of bloom buds is the sudden occurrence of cold or cool weather, coming at a time when the plants in the tomato field are in active blooming condition. The temperature is too low to permit the pollen to fertilize the ovaries, and consequently, the blooms drop off. In cases of this kind we have no effective remedy, but have to wait for favorable weather. This condition does not usually continue for more than a few days at a time. It, however, does occasionally happen that we have a period of ten days or two weeks during which we have continuous cold, raw winds. In addition to this cold weather causing the bloom to drop off for want of fertilization, the after effect of the cold is shown by the plants being debilitated to such an extent that a considerable period follows during which the tomato blooms do not set.

Just the opposite condition may sometimes occur. Plants may grow too rapidly, especially if the formula of the fertilizer used is high in ammonia and the weather is favorable to the most rapid growth. In this case the tomato plant grows very rapidly and grows to weed instead of producing fruit. When this is the case the vegetative function of the plant is carried on too rapidly to allow fruiting. Fortunately, this condition is under our control. In the first place, we should use a fertilizer that is not too one-sided in ammonia content; but we must reckon with the fact that a fertilizer which would prove to be the very best during a dry year would prove to be too high in ammonia during a year when the amount of moisture was normal or above the normal. Where the bloom buds are shed on account of too rapid growth of the vine, this condition may be checked almost immediately by cutting out the growth buds at the terminals of the plants. Care should be taken to leave at least two "hands" of bloom buds. This makes the process of disbudding a little more tedious, but if all the bloom buds are removed the plants will not be able to set any fruit. In disbudding rapidly-growing plants to make them set fruit, care must be taken not to carry this operation to an extreme; otherwise, we introduce a disease which is known as leaf curl, or roll leaf, and is described in subsequent pages.

A third cause for the dropping of many blooms is due to the presence of a minute greenish insect very similar to the suck-fly of the tobacco, which has a pernicious habit of spending most of its time on the bloom buds of the tomato plant. By means of its slender beak it pierces the stems of the fruiting hands, and in this way injures them to such an extent as to cause the shedding of buds, and even, in severe cases, to cause the droppings of newly set fruit. The insect is rather shy, and not readily discovered, especially if the tomato plant is brushed against or moved. If, however, the observations are made very quietly, there is no difficulty in finding one or more of these small flies engaged in its disastrous work.

The life history of this insect has not been carefully studied out so far as the writer knows, but the mature insect may be killed by spraying with a nicotine solution, and by some of the other contact insecticides. It is, however, a rather difficult matter to get the insecticide on the pest, because at the least disturbance of the vines it flies away and gets out of danger by hiding under a leaf.

Leaf Curl, or Roll Leaf.—The appearance of the plant when affected by this disease is so striking that all tomato growers are familiar with it. There are a number of causes which lead up to this difficulty. The most important one in Florida is the presence of too much moisture in the soil. Another very prolific cause of this disease is the too severe pruning of the tomato plants. Where this is carried on rather drastically, it is almost certain to produce the disease. As disbudding is practiced by many of our growers, and staking of tomatoes is also customary over a large area, we find this disease not at all uncommon. The bad effects of it, however, are as a rule not recognized, since the leaves usually remain green and the plant continues to grow. A plant, however, that has been pruned or disbudded to the extent of producing leaf curl is less productive than one that has not been pruned to such a degree.

Where leaf curl is due to too much moisture in the soil, care should be taken to plow the field in such a way as to relieve it of the superabundance of moisture. Where leaf curl is due to pruning, the pruning should be discontinued, or deep plowing, and plowing rather close to the plant, followed. This plowing will in a measure relieve the soil of the surface moisture, and at the same time do a considerable amount of root pruning. In this way we cut off a portion of the moisture that would otherwise be taken up from the soil.—(Fla. E. S. B. 91.)

Mosaic Disease.—The so-called mosaic disease, which is common to tomatoes, is characterized by a peculiar yellow spotting of the upper surface of the leaves. These yellow spots, particularly when exposed to bright sunlight, subsequently become purplish in color, and the margins of the leaves curl up. We have observed many crops badly affected with what is termed mosaic trouble, and in all cases this is associated with too extensive pruning. The more a tomato plant is pruned the more likely it is to be affected with the mosaic disease, and topping or pruning of the leaders induces this trouble more than other methods of pruning.

The mosaic disease is apparently a functional trouble, and little is known about it. Similar troubles are associated with tobacco (calico) and are believed to be infectious. The presence of this disease on tobacco is thought by some to be associated with certain methods of transplanting. The disease on tomatoes does not destroy the foliage of the plant, but the abnormal metabolic processes which appear to be associated with this disease apparently affect the yield.

Sleeping Disease or Wilt.—The disease does not usually show itself until the plants have attained full size and begun to bloom.

Clinton characterizes the disease as follows: At first a lower leaf or two will wilt, turn yellow and finally die. Gradually the disease works up, successive leaves drying up and dying on the vines. Microscopical examination shows a discoloration of the vascular bundles of the leaf petioles and stems, which are more or less filled with the mycelium of the fungus. This causes a clogging of the vessels and interferes with the transference of water, resulting in wilting. The fungus infects the plant through the soil, and sterilization might succeed in preventing infection.

SWEET POTATO DISEASES.

Sweet Potato Black Rot.—The most conspicuous sign of the disease, and the one which distinguishes it from other diseases, occurs upon the potatoes themselves. It consists in the presence of dark, somewhat greenish spots, varying from a quarter of an inch to 4 inches in diameter, sometimes covering the greater part of the root and extending some distance into the tissue. These spots when once seen can not be mistaken, as they are simply sunken areas with distinct margins, like spots burned into the potato with a metal dye which has left the skin uninjured. Should the slightest doubt as to the identity of the disease remain after a superficial examination, the removal of a small portion of the skin exposing the olive-green tissue below would dispel it. Among the sprouts, or young plants grown in hotbeds, the disease manifests itself in dark lines upon the lower portion of the shoot and sometimes of the lower leaves, giving rise to the name of "black shank" among the growers. These dark lines or blotches often appear upon etiolated portions of the stem and are almost black in color. In very severe cases the tip of the sprout wilts and dies. No appearance in the field has so far been observed that would distinguish hills diseased with black rot from those attacked by some other of the numerous rots; but the dark sunken areas on the potato and the black discolorations of the sprouts can scarcely be confused with any other sweet-potato disease. This infection may take place either through the medium of spores or by the growth of mycelium from the diseased areas themselves. Diseased sprouts planted in the field produce diseased roots which may spread the disease to other hills either through the soil directly or by means of the numerous fibrils from other plants. These infected areas, although perhaps inconspicuous at first, grow steadily in diameter not being checked by digging, and when the potatoes are stored for keeping continue to grow in the root and at the same time to produce the various forms of spores. These reproductive bodies when supplied with sufficient moisture are capable of infecting, unaided, sound potatoes through their eyes. Thus one diseased potato when stored in a bin of healthy ones is capable of infecting all those in the bin and causing them to rot in a short time.

1. The most important precaution to be taken in combating the disease is to plant only perfectly healthy seed in the hotbed, even if it is necessary to import such. This preventive measure is most essential, as diseased seed will give diseased sprouts, which in turn will grow a crop of worthless potatoes.

2. The selection of healthy sprouts is plainly necessary in case the fungus gets into the hotbeds, and under no circumstances should diseased plants be put into the field. The test of using copper fungicides in the hotbed has not been made, but from analogy seems to promise assistance. If the fungicide is used the shoots should be kept green with it until pulled.

3. Fields which have become so impregnated by the disease that they refuse to grow profitable crops had best be added to the regular farm rotation. This method will, if continued for several years, allow the accumulated infective material to burn itself out by consuming all available food material in the soil.

4. Decaying roots and the refuse after digging should be carefully removed from the field and burned, as such debris adds to the food of the parasite.

5. The use of large quantities of barnyard manure probably favors the development of the trouble, since it adds greatly to the decaying vegetable matter of the soil. Where the use of commercial fertilizers can be made to take the place of manure it will certainly be desirable to make the change.

6. Although no experiments have yet been completed upon the matter, it is probable the spread of the disease in the bin may be checked by dipping the roots in one of the copper mixtures, preferably the ammoniacal solution, before storing for the winter. What effect tobacco smoke or the fumes of sulphur would have in checking

the disease in the bins remains to be ascertained.—(Journal of Mycology, Vol. VII, No. 1.)

Stem Rot—Wilt.—The plants gradually die and wither away in the field, the stem and roots being affected by this dry rot fungus. Use seed from an uninfested locality and plant on fresh land as far as possible. Gather and burn all affected vines.

Soft Rot.—A soft decay of the potatoes in storage, caused by a black mold which appears on the surface. Handle the potatoes carefully while green and let them cure or dry thoroughly before storing. Pack in dry sand for long keeping.—(Cal. E. S. B. 218.)

MALNUTRITION DISEASES OF TRUCK CROPS.

While the diseased condition does not manifest itself in precisely similar symptoms in all crops, there are a number of points of general resemblance.

1. The plants stop growing when they should be making their most rapid development. In many cases they slowly weaken and die, while in others growth is resumed later in the season after rains have occurred.

2. There is a change of leaf color to a lighter green, especially in the spaces between the veins, which turn yellowish-green or even brown. In cabbage the margins of the leaves are frequently of a uniform yellow color.

3. The roots of the affected plants are poorly developed. Many of the lateral feeders are killed back repeatedly, until the root system becomes stubby.

4. No fungi or bacteria can be connected with the disease. In most cases none are present.

Causes of Malnutrition.—The most prominent conditions discovered in land subject to this trouble were their acidity, deficiency in humus, and the absence of desirable nitrifying bacteria. Each of these factors doubtless contributes towards the diseased condition of the crop.

Acid soils are less favorable for the production of most truck crops than neutral soils. A slight amount of acidity is not ordinarily injurious, but examinations made at our request by the Bureau of Soils of samples from fields where cabbage suffered from malnutrition, showed these soils to be abnormally acid, so much so that 3,500 to 6,300 pounds of lime would be required to neutralize an acre to a depth of one foot. This condition is apparently the result of many years of intensive trucking, involving the use of repeated heavy applications of commercial fertilizer made up in large part of chemicals which leave the soil more acid.

Only a portion of the fertilizer applied is actually taken up by the plants, the remainder being left in a different form which will have an influence on the soil reaction. For example, sulfate of ammonia, muriate and sulfate of potash, and acid phosphate tend to leave the soil more acid, while nitrate of soda, carbonate of potash and Thomas phosphate tend to make the soil alkaline. In the brands of fertilizers most used in this section, the acid forming ingredients largely predominate.

Isosoma Grande. Pupa of Summer. Form in Young Wheat. Dept. of Agr.

Stalk of Wheat Covered with Dead Greenbugs Killed by Parasite. Dept. of Agr.

One of the most important factors contributing to malnutrition is the exhaustion of the organic material in the soil. Fields where this disease occurs are found to contain only 1.65 per cent of organic matter, while normally 3 to 5 per cent should be present. This deficiency is to be expected from such complete dependence on commercial fertilizers, which cannot take the place of stable manure and green manures in a permanent system of agriculture.

The fields used for the experiments quoted were given a bacteriological examination by the Office of Soil Bacteriology of the Bureau of Plant Industry, which reports that the nitrifying organisms which should be present in a fertile soil were deficient in numbers and nitrifying powei. This is to be attributed to the acidity and deficiency in humus already mentioned.

Remedial and Preventive Measures.—The course to be adopted for the correction of these difficulties should be a matter for the earnest consideration of everyone, not merely of those whose fields are already injured.

The practices that have developed these nutrition disorders in the cases reported are still followed by a majority of our truck growers, who may look forward to a further deterioration in the crop-producing power of their soils unless they profit by the errors of their neighbors.

Briefly stated, the points needing most attention are: 1. Limitation of the amounts of fertilizers used. 2. Adjustment of the composition of the fertilizer to suit the crop requirements. 3. The rational use of lime. 4. The maintenance of the organic matter of the soil.

Amount of Fertilizer Most Profitable.—The indications are that the limit of profit is often exceeded by truck growers and that in many cases actual injury results from the use of too large amounts of commercial fertilizers. In the field experiments conducted on land subject to malnutrition, larger yields of cabbage were obtained from 1,000 pounds per acre than from any higher application.

Doubtless other fields richer in humus would repay higher fertilizing. The most profitable amount of fertilizer will have to be determined for each field and for each crop, which varies from season to season. Three points are borne in mind. 1. That the use of large amounts of quickly soluble materials may result in direct injury, "burning" the plants. 2. The large application may not be utilized by the crop because of the lack of some necessary ingredient. Thus, if lime is lacking the plants can assimilate only a limited amount of potassium and phosphorus, even though they may be present in liberal quantities. Absence of lime frequently appears to be the limiting factor in this section, and much fertilizer is wasted because the crops cannot use it until lime is supplied. 3. Our experiments leave no doubt that the malnutrition disease described may be induced by too heavy application of fertilizers.

Composition of Fertilizers.—Hitherto attention has been directed chiefly to the proportions of nitrogen phosphoric acid and potash contained in a fertilizer, and these are the only points covered by the manufacturers' guarantee.

It has, however, long been known that the source of each of the above elements was a matter of importance. The nitrogen varies in its effects according as it is derived from nitrate of soda, sulfate of ammonia, cotton-seed meal, fish scrap, dried blood, etc. Phosphoric acid is usually from acid phosphate, but may be from bone, or Thomas slag. Potash may be in the form of sulfate, chloride or carbonate, or from still other sources.—(Vir. Truck E. S. B. 1.)

DISEASES OF GRAIN AND FORAGE.

ALFALFA—LUCERN.

Anthracnose.—Two new anthracnoses have been discovered attacking alfalfa; the first of these, *Colletotrichum trifolii,* so far as known occurring exclusively on plants of this family, the other, *Colletotrichum,* occurring only on alfalfa in northern Ohio. The first one, which we may call clover anthracnose, was discovered in Tennessee and has appeared upon alfalfa as well as red clover in the southern portion of Ohio. It is less prevalent on alfalfa than upon the red clover. Up to this time this disease has not been discovered upon either host in the northern half of the state. The second anthracnose occurred recently upon alfalfa from Sandusky and Carroll counties and has not been described. Both of these diseases show as a specific lesion or diseased spot on the stem or leaf-stalk in the advanced stages of attack. Following this the plants wilt or die and are discovered in this way. The disease is too new with us to measure its injuries directly. To the writer it appears less serious than the dodders or the root-rot troubles.

Bacterial Blight (*Yellowing*).—A bacterial blight of alfalfa, of which the casual organism has not been definitely determined, has been reported from Colorado where it appears to be spreading. In 1907 and to a still greater extent in 1908, there was much complaint of general yellowing of leaves of second crop alfalfa in Ohio and adjoining states, even extending to North Carolina. The symptoms were general yellowing of this crop. With brighter, drier weather later the next succeeding crop was of normal color. Bacteria have been found by the assistant botanist in connection with this trouble in specimens from eight localities and from four different counties in Ohio during 1908 and 1909.

Downy Mildew.—The downy mildew fungus (*Peronospora trifoliorum*) has occurred in Colorado, and is very liable to occur in other states. No suggestions can yet be made as to its prevention.

Leaf-Spot Fungus.—This forage plant is grown in parts of Ohio. It is attacked by the leaf-spot fungus (*Pseudopezia medicaginis*) which is found upon both leaves and stem. The small dark spots produced by it are easily seen. In attempts to produce alfalfa seed at this station, the fungus has stripped the leaves and seed capsules before maturity. It is very likely to prevent success in growing this seed in Ohio, though it is much less injurious to the forage crop proper because of cutting at short intervals.

Root-Rot.—The same parasitic fungus (*Fusarium roseum*) which attacks wheat in the form of scab and also red clover, has been found killing out alfalfa at Wooster (See Ohio Bulletin 203). This fungus may survive in stubble fields where wheat and oats have been grown. It readily kills off the young seedlings of alfalfa and if the soil is not fully prepared for alfalfa seedings, the root-rot may extend its work and further destroy the stand. At present nothing better is known than adequate dressings of lime, preferably raw limestone, for areas to be seeded, together with their proper enrichment. At this time warning is given as to the possible seriousness of this trouble in the future. While not specifically noted in America another root-rot fungus somewhat known on other crops (*Rhizoctonia*) has also been reported upon alfalfa from France. Another root-rot fungus (*Ozonium omnivorum* Shear) well known upon cotton, also attacks alfalfa in the southwest. It is believed this is not known to occur in Ohio.

Rust.—Alfalfa suffers from a rust fungus (*Uromyses striatus*) and while it may scarcely have appeared in Ohio, it is almost certain to do so in time. Like the similar leaf diseases of red clover, it may have rather small economic interest.—(Ohio E. S. B. 214.)

BUCKWHEAT.

Leaf-Blight.—This well known plant is frequently attacked by a leaf-blight fungus (*Ramularia rufo-maculans*) which produces whitened areas on the under leaf surfaces and causes dying of these leaves. It is not known to be sufficiently destructive to warrant treatment for prevention. Another leaf trouble referred to a fungus (*Fusicladium fagopyri*) is reported from Europe, but is not known in this country.

CLOVER.

Anthracnose.—Three anthracnoses occur upon clover; the more common of which is due to the same fungus (*Colletotrichum trifolii*) as the anthracnose of alfalfa. In 1907 it attacked the clover over the southern one-third to one-half of Ohio, causing dying of the plants attacked. These show lesions of the stems and leaf stalks and may be detected in the new seedings in late summer through the dying of the leaves of these plants. It is not known how serious this may prove upon clover, nor is this one known in northern Ohio.

The second anthracnose fungus (*Gloeosporium trifolii*) has been known longer than the first and occasionally shows by killing the tops of large clover stems in meadows. It is apparently not a serious disease, although a very interesting one to study in connection with the anthracnoses due to Colletotrichum.

The third anthracnose upon clover (*Colletotrichum cereale*) is the anthracnose of wheat, rye and oats. It was found to a limited extent attacking clover upon the Ohio station grounds in 1909. Except in microscopic characters this anthracnose cannot be distinguished from that of Bain and Essary first mentioned above. In the microscopic characters the two are clearly distinguishable. It is quite probable that this fungus will be found over much of the state.

Black-Spot.—This is due to a fungus (*Phyllachora trifolii*) which attacks the leaves of clover causing dead spots and dark discolorations on the under side of the leaves. As a rule these attacks come so late in the working life of the leaves that the injury is slight.

Leaf-Spot.—A leaf-spot of white clover referable to an anthracnose fungus (*Ascochyta*) has been described from our region although not definitely determined in Ohio. The injury which may result cannot be now stated.

Rust.—The various sorts of the cultivated clover, Red, Alsike, Mammoth, etc., are attacked by a clover rust (*Uromyces Trifolii*). If one will examine the small, dark spots in the clover leaves he will find a cluster of this reddish fungus beneath. This rust does not spread to other plants than clovers and is commonly regarded as more disfiguring than destructive. It is not nearly so injurious as the leaf-spot of alfalfa which is similar in appearance.

Root Nodules and Root Tubercles Upon Leguminosae.—Upon removal of the roots of the clover plant from the soil one finds minute enlargements which are the subject of frequent inquiry. These are nodules or tubercles as they were formerly called, caused by the messmate-living of certain nitrifying organisms, or microbes, with the clover plant. To these microbes in this communal life is due the power of withdrawing nitrogen from the atmosphere and fixing it in the tissues of the clover plants. The same applies in general to the nodules upon plants of this order, the *Papilionaceae*. It thus follows that these nodules are the normal condition of properly nourished leguminous plants of the order *Papilionaceae*, and it likewise follows that the full value of this work of nitrogen fixing is only realized for manurial purposes when the tissues of the clover plants decay in the soil.

Clover Dodder—(*Cuscuta epithymum*).—Clover dodder is an old enemy and is well known throughout the country. Judging by its prevalence on clover during the summer of 1907, it seems probable that its nature is not thoroughly understood by the farmers. The disease was very common in all parts of the state where red or alsike clover was grown, and was much more abundant than it has been in previous years.

Dodder on Clover.—The dodder of clover is recognized at a distance by the yellow appearance in spots of the clover fields. At close range, it will be seen to consist of branching yellow threads which twine about the stems and leaves of the plant. At first the dodder will be seen only in a small area, infecting one or two plants. It rapidly spreads in all directions by branching of the threads from these to other plants till large areas are covered. During this spreading, the plant first infested will gradually be killed by the parasite. The dodder dies with it, but continues to grow along the edges of the spot, so that, in the late season, dead spots surrounded by a circle of dodder-infested plants may be observed in clover fields. The dodder in the meantime has blossomed profusely and ripened its seed.

Dodders in General.—The dodders, or love-vines, are parasitic flowering plants closely related to the morning glories, or bind weeds. There are several species occurring in this state besides the one which attacks clover. Most of these grow on weeds, particularly in moist bottom lands, and do no damage to the farmers' crops. These plants are peculiar in that they are parasitic in habit, depending on the plants upon which they grow for their food, instead of elaborating it for themselves from the soil-moisture and air, as plants possessing green color are able to do. Dodders are destitute of this green color, called chlorophyll, and so have not the power of elaborating food for themselves. The plant consists of a yellow stem which is practically leafless.

Methods of Eradication.—When occurring in small areas, the following methods of eradication may be practiced:

1. Cut and rake to the center, the infested plants in the spots, and burn. Cut the clover one yard in all directions outside of the apparently infested area, to be sure that no branches are missed. For complete eradication this cut area should be hoed to a depth of 3 inches for about three weeks. This allows the scattered seed to germinate and die. If the spots are cut early before the seeds are ripe, this cultivation is unnecessary.
2. Sprinkle infested spots with a 10 per cent solution of sulphate of iron, or potassium or copper. This is best applied to the stubble after the spots have been cut and burned.

If the dodder covers large areas so that the above suggestions are impracticable, the following may be practicable:

1. Close grazing with sheep or cattle for some time.
2. Rotation with crops which involve cultivation for two or more seasons.

Dodder may be introduced through baled hay and the seeds spread through manure. Thus hay infested with dodder should never be used, as it may be spread in this way to all parts of the farm.

Seed Inspection.—The best method of keeping dodder off the farm is to prevent its introduction by rigid seed inspection. Dodder is usually introduced through impure seed. It is probable that great numbers of cases where dodder appeared recently were directly traceable to the use of impure seed. The seed of clover dodder are smaller than red clover seed, and by close screening may be separated.—(Del. E. S. B. 83.)

CORN DISEASES.

The Blight of Corn.—This disease first seemed to be almost entirely confined to late planted corn, that which was planted as a second crop. The disease is caused by a parasitic fungus, *Helminthosporium inconspicuum,* which makes its appearance on the leaves as a greenish mold visible in mass to the naked eye. This growth is found on discolored, elongated spots, their width being often limited by the veins of the leaf. This is no new trouble, but appears to have done more than the usual amount of injury in Delaware during the past season. The blight causes on corn leaves long dead or yellowish colored spots, upon which the dark colored spores of the fungus are produced.

After a time the entire leaf is so affected that it dies, although often only the tips are diseased. The general appearance of a diseased field resembles very much one that has been frost bitten. The fungus occurs early in the growing season, July and August, but thus far it has never been reported as injuring corn seedlings. This disease has the power of killing the partially matured plant. This means a shorter growth and immature stalks. It not only causes less amount of fodder, but if intended for ensilage the corn is likely to die before the farmer would think of cutting it, so he has dead dry fodder instead of green for his silo. If the corn is intended to produce ears the disease so weakens the vitality of the plant as to prevent proper maturing of the crop.

The disease occurs at such an advanced stage in the growth of the corn that at present no remedy seems practical. In all probability the spores would live after passing through the ailmentary canal of an animal and so spread the trouble the following year. It seems advisable, if the corn was diseased the previous year, not to use manure made from it on land intended for corn. A rotation of crop is also advised.—(Del. E. S. B. 63.)

Corn-Smut.—Every farmer is familiar with corn-smut. The largest masses are sometimes over 6 inches in diameter and are usually found in the ear. Smut is also found in the tassel, on the leaves and stem, and even on those roots which hold the corn-plant to the soil. The smut-mass is blackish, and is at first covered by a whitish film, which soon breaks and lets loose the spore-powder, which is blown about by the wind. How, by these spores, the disease lives through the winter, and then gets into the corn-plant, has been described above. In general, there are two ways by which the spores get back on the land, ready to infect the next year's crop. First, they may be scattered by the wind, or the smut-masses may be left on the field. Second, the smut-dust may get into the fodder and may pass through the ailmentary canals of the cattle, without being injured, and may thus get into the manure-pile. Or again, the smut-masses may be thrown into the refuse or manure-pile. In either case they may be carried back to the soil when the latter is manured. Now, it is an important fact that the smut spores not only may live through the winter in the manure-pile, but that they may actually increase in number by growth when the pile remains of proper temperature. Fresh manure containing smut is therefore very likely to increase smut in a corn-field. The smut may live for several years in a manure-pile, but will gradually die out. For this reason, old manure is much better for fertilizer on a corn-field than fresh manure.

Since the smut-masses that are left in a corn-field may assist in spreading the disease, they should be cut out of the corn-field during the growing season. They should, moreover, be cut out before they have fully opened up and spread their spores, and should be collected and burned. They should not be thrown on the manure-heap or refuse-pile, thence to be carried back to the land.

Rotation of crops is valuable in preventing corn-smut. The reason for this is plain. The corn-smut in the soil will not live many years, and that which is in the soil will not damage any other farm crop. After several years, corn may again be planted, with less danger, since the smut in the soil will have at least partly died out. Seed-treatment has not been found to be of any use. The smut does not get into the seedling plant, as in the stinking smut of wheat, and hence seed treatment does not seem necessary.

As to the treatment, since an infected seed has no spores on the outside, but has the smut inside of the seed, some methods have to be devised other than those used for smut of wheat and barley. Such are described below. They are, briefly, built upon this principle: The seed is soaked in cold water for several hours. In its water-soaked condition, heat can be carried through the seed more uniformly and quickly than when it is dry. The soaked seed is then treated in hot water, and then the smut-plant inside of the seed is killed; while the seed is not at all, or only slightly, injured by the treatment. For further details see below.

Since the treatment for one group of smuts may have no effect on the other, it is absolutely necessary for a farmer to know which smut he is dealing with. It then becomes an easy matter to apply the proper remedy. For instance, in treating smut in barley, a farmer who treats his barley with the formalin method will get rid of the covered smut of barley, but will *not* get rid of the loose smut of barley. The same holds true of wheat. In order to get rid of the loose smuts of these crops, the modified hot water treatment must be used.

There is another smut, not described above, which is found on sorghum plants, but this smut has not yet appeared, at least in any quantity, in Minnesota. It is known as head-smut of sorghum. The life story of this smut is not yet known; but it is undoubtedly different from grain-smut of sorghum, described above, since the ordinary formalin treatments have no effect on it.—(Minn. E. S. B. 122.)

BARLEY.

Closed Smut.—The grain is turned a dark color by the formation of the fungus spores in its substance. This remains firm rather than flying out in a dusty mass, as in the next form.

Loose Smut.—Differs from the last in that the smutty substance of the grain scatters out in the form of black dust, leaving the heads empty. Barley is not often affected with smut in California, so that we can not distinguish as to the occurrence of these two different species. It is advisable, however, to treat the seed as follows: Soak for 10 minutes in one of the following solutions:

1. Bluestone, 1 pound to 5 gallons of water.
2. Formalin, 1 pint to 30 gallons of water.

The seed should be soaked long enough to get every grain thoroughly wet and then immediately taken out. If not planted at once the grain must be dried before storing. Plant a little more seed after this treatment than would be used with untreated grain. Loose smut alone is more successfully controlled by the following seed treatment: Soak in cold water for 5 hours. Then soak in water at a temperature of 125 degrees F. for 15 minutes.—(Cal. E. S. B. 218.)

BLUE-GRASS.

Anthracnose.—This shows as black spots on the stems and basal sheaths, and will evidently survive on this pasture grass. The injury is greater upon wheat, rye, oats and clover, under which illustrations are given, than upon blue-grass.

Bacterial Blight of Head.—In this case the bacteria appears to enter the upper sheath and cause a lesion above the upper joint. This ends in the death and the drying up of the heads.

Powdery Mildew.—The foliage of the blue-grass is attacked by the conidial stage of the wheat mildew (*Erysiphe graminis*). This fungus gives little evidence of injury, though its presence is certainly *not* beneficial and the perithecia of the parasite are not common on this host.

Rust.—Blue-grass is likewise attacked by a rust (*Puccinia graminis*) which is general on grasses.

Smuts.—A smut fungus (*Ustilago striaeformis*) attacks the blades of blue-grass though it is possibly not often very injurious.—(Ohio E. S. B. 214.)

MILLET.

Leaf-Spot.—Leaves of millet, dying from small, light-colored spots, were recently examined. These spots are due to a fungus (*Piricularia grisea*) and the dying may at times be enough to shorten the yield of forage.

Smut.—The seeds of millet are often attacked by the millet smut fungus (*Ustilago Crameri*) which transforms them into black masses of smut spores, much after the manner of stinking smut in wheat. This is liable to injure the feeding value of the millet, although it is not likely that the smut will injure stock when millet is fed in the usual quantities. All smutted grain, of course, is ineffective and useless, and the smutted seed when again sown will produce a smutted crop. The smut is prevented by the same hot water seed treatment as that applied to prevent oat smut. In experiments conducted by the botanist of this station this treatment was successful.—(Ohio E. S. B. 214.)

RYE.

Rye Anthracnose.—This new disease was very serious upon rye in 1908 and was surely prevalent in 1907. The spores are carried by adhering to the seed grain and can be discovered in centrifuge separations of grain washings. In rye fields the anthracnose attacks both the heads and the lower portions of the culms. The localized attack upon the head (rachis) kills all that portion of the spike above the point of attack and the grain is but partly developed. Upon the bases of the stems, including the roots, the fungus develops its dark masses often closely packed together and dotting both stem and sheaths. In 1908 the loss of yields in rye were from 25 to 60 per cent of the total crop.—(Cal. E. S. B. 218.)

TIMOTHY.

Anthracnose.—This occurs upon timothy and as already noted on blue-grass, orchard-grass, red-top, wheat, rye, etc. The attacks so far studied, are confined to the culms and sheaths upon the lower part of the stems showing small dark masses of the anthracnose fungus as spots upon them. This shows that the timothy is liable to carry over the disease between the wheat crops.

Bacterial Blight of Head.—See blue-grass.

Rust.—Some seasons this is very prevalent upon timothy resulting in much spotting and premature drying up of the foliage. This was true to a notable degree in Ohio in 1908.

Smut.—This attacks the blades of timothy and produces interesting developments in them. As a rule the amount of smut is not serious. (See smut of blue-grass.)

OATS.

Anthracnose.—This is a new disease of oats which attacks the roots and basal portions of the culms together with the lower sheaths. The attack may extend even further than has yet been determined. The spores of this fungus were found adhering to seed oats of the crop of 1907 and the outbreak of the disease was studied in 1908. It shows by the development of the characteristic dark masses or acervulæ of the anthracnose fungus upon the lower joints of the stem, portions of the root and leaf sheaths.

The amount of loss resulting from it is liable to be variable since it acts by general reduction of vigor and reduced filling of the grain head. Treatment with formalin as for smut will certainly kill the adhering spores on seed oats.

Blade Blight.—A disease similar to that earlier described as bacterial disease of oats has been very serious in Ohio during the seasons of 1907 and 1908. The phenomena are those of yellowing and dying of older leaves associated in most cases with the presence of an abundance of leaf sucking insects such as aphids, mites and leaf hoppers. Recent culture and colonizing studies made at the station show the disease to be due to two specific bacteria working together—(*Bacillus avenæ* and *Pseudomonas avenæ*). These have been isolated and described. These bacteria are carried or transmitted by the insects or are scattered by natural agencies. In control work in cages the organisms caused infection through the punctures of the aphids (green flies.) Evidently the control of this disease will involve thorough seed treatment together with possible field checking of the insects distributed.

Rust.—In addition to the two species of rust found upon wheat and to be given under that grain, there is a rust common upon oats (*Puccinia coronata*), usually prevalent during the rainy harvest weather and more or less at all times. No remedy is as yet at hand.

Scab Fungus.—This is the same species as for wheat and attacks the panicles near filling time. It results in empty hulls with the pink fungus. The disease also survives apparently as an internal infection of oat kernels and is capable of destroying young seedlings after the manner described for wheat. (See Diseases Transmitted in the Seed and also Wheat.) Like that disease in wheat, it must be controlled, if at all, by a combination of seed treatment for adhering spores and thorough seed recleaning to exclude all light kernels.—(Ohio E. S. B. 214.)

Loose Smut of Oats.—The loose smut of oats is a disease that is more or less common, some years more than others, wherever that crop is grown unless measures have been taken to prevent its occurrence. The disease is caused by a fungus growing within the tissues of the oat plant. This fungus eventually transforms practically the entire head to a black dusty powder. Such smutted heads are to be found, usually very readily as the oats are heading out, borne on stalks somewhat shorter than normal as a rule, because of the diseased condition, and consequently easily overlooked. Later, at harvest time, practically all of this powdery dust has blown away and scarcely anything but the skeleton of the head remains. This is very inconspicuous and easily overlooked. Because of these two reasons, oat smut is frequently underestimated.

The black powdery dust of the smutted head is composed of innumerable, minute bodies, nearly or quite globular, the spores of the smut fungus. These smut spores mature thus in the smutted heads and, being light, are blown about by the wind like dust just at the time when the healthy oats are in bloom. In this way the spores easily get on to the young sound kernels that are to become the seed for next year's crop. Many smut spores cling to the oat kernels often safely protected within the chaff. When the oats are sown in the spring, the same conditions that favor their germination and growth favor the germination and growth of the smut spores. These latter soon push out minute germination tubes which grow into the tissues of any very young oat plant within reach. Here the smut fungus grows in the form of irregularly branched tubes and absorbs nourishment from its host; nourishment that the oat plant itself should use in producing growth and seed. The smut fungus keeps pace with its host through the season often branching to all the stalks of a stool. The slightly dwarfed condition of the host, which usually occurs, is the only effect of the smut to be seen until the diseased plants head out. Then, instead of a sound head, one appears with kernels and chaff wholly or in part changed to a black dusty powder, masses of spores of the fungus. These spores are now ready to be blown about to find lodgment on sound young oat kernels where they may remain ready to infect the crop the following year after being sown with the seed in the spring. In this way, then, the oat smut fungus lives over from year to year and spreads.

Since it is by way of the seed that the disease is carried over from season to season, it is at once apparent that any practicable method of seed treatment that will kill the smut spores without injuring the vitality of the seed is the point of attack. Several methods are known that meet these requirements and the application of some of them for the prevention of oat smut has long been out of the experimental stage. As with many other things, the method used, if efficient, is usually less important than the care and thoroughness of the application. Among the different methods, the formalin treatment still stands unsurpassed for convenience of application and when properly applied is equal to any other in efficiency.

The formalin treatment is very simple. It may be applied with but very little trouble and much profit by any farmer who has loose smut in his oats. The treatment is as follows: Spread out the grain to be treated on a floor or canvas and sprinkle until thoroughly moist with a solution of one pound (about a pint) of formalin to 50 gallons of water. Shovel over repeatedly while sprinkling and afterward so as to distribute the moisture evenly. It is very important that every kernel be thoroughly moistened so that the attached spores may be killed. When thoroughly and evenly moist, not quite wet enough to pack in the hand, the grain should be shoveled into a pile or clean bin or wagon-box and covered for at least two hours with sacks or canvas. This time may be increased to over night, if more convenient, without injury to the grain. The seed may now be sown at once. In sowing at once the seeder or drill must be set to sow somewhat more to the acre in order to make up for the swollen condition of the grain. In order to sow two and one-half bushels of oats the seeder or drill should be set to sow about three and one-half bushels. (Wheat: in order to sow one bushel and four quarts, drill should be set to sow one bushel and 18 quarts.) If grain is to be kept longer than over night, it should be dried as rapidly as possible by spreading in a thin layer, where there is a moderate circulation of air, and stirred occasionally with a rake. Thorough drying is highly important if grain is to be kept any length of time, for otherwise it will soon heat and spoil entirely. It is usually best to sow as soon as possible after treatment. Care should be taken to avoid reinoculation of treated seed with smut in handling after the treatment, as by using smutty sacks or bins, etc. These may be disinfected by thoroughly wetting for two hours with the formalin solution used for treating the grain. This time may be shortened by using double strength solution. Placing sacks in boiling water for a few minutes is also effective.

In general it is usually best to treat the seed each year unless it is very certain that no reinoculation of the clean crop has taken place either from smut in fields near by, smut spores being carried by the wind, or from smut spores carried by the threshing machine after threshing smutted oats on another farm, or from any other such source. It is at once apparent that to eradicate oat smut entirely from a community would require the thorough cooperation of all oat growers over a large area. This would be most desirable, but in general, treating the seed each year, or at least every second year, is the safest and most practicable procedure.

WHEAT.

Stinking Smut of Wheat.—This, sometimes called bunt, is quite different from the loose smut of oats in many respects, yet its mode of attack is similar. The two are taken up together in this publication chiefly because of the similarity of preventive measures. The occurrence of stinking smut of wheat over the state is not so general as that of either the loose smut of oats or the loose smut of wheat. The stinking smut of wheat occurs only where smutty seed wheat has been used or clean seed has been inoculated with such smut spores in some way in handling. Where this disease does occur, however, it is usually far more destructive than the loose smuts of oats or wheat, sometimes destroying as much as one-half of the crop or even more, and rendering the remainder almost worthless. The same method as with oats can be used for estimating the percentage of smut present in any field. In addition to the amount of grain actually destroyed by the smut, the sound wheat that remains is heavily docked on the market because of the well known fact that such wheat produces flour of very poor quality. It is therefore important to give special attention to keeping this smut from the crop or eradicating it if it is present. This can be done. It is necessary, however, to know something of the habits of the fungus which causes the disease so as to be able to proceed intelligently to combat it.

Development and Spread of the Disease.—The stinking smut of wheat is caused by a parasitic fungus, which, like the oat smut fungus, is carried over from year to year by spores attached to the kernels of the seed grain and sown with them. Infection of the very young wheat plants takes place in a way similar to that with oats. The fungus grows up within the tissues of its host and when the latter heads out the parasite enters the young kernels and transforms the contents of each into a dark brown, dust-like, somewhat greasy, ill-smelling mass, the spores of the fungus. The disagreeable odor given off by this smut, from which character it gets its name, is often so striking at harvest time that it is sometimes noticeable to a considerable distance on the windward side of a badly affected field. This odor is especially noticeable when such wheat is threshed and for some time thereafter in the product.

Thus, instead of heavy, well filled heads of sound wheat, the diseased plants produce heads that are worse than worthless. Such heads are very light and consequently remain usually quite erect. The glumes or chaff of the affected heads are not attacked by this smut. They are, however, often abnormally distended by the short, puffy smutted kernels, which sometimes show between them. In general appearance the smutted heads are similar to the sound ones; when the smutted kernels are examined, however, a rather striking difference is at once evident. The smutted kernels or smut balls are of a dead, light brown color, often with an olive green tint. In form they are usually shorter and thicker than the sound kernels and the characteristic deep crease of the latter is no longer present. This gives the smut balls their characteristic puffy appearance. The smutted kernels remain whole until broken in some mechanical way in handling the grain. When thus broken the spores attach themselves to anything with which they come in contact, such as the threshing machine and all other sorts of machinery and implements, bins, sacks, etc., that the smutty grain touches. As a consequence of this, clean wheat passed through any such channels, through which smutty wheat has just passed, takes up the spores, and if used for seed without treatment the resulting crop will be almost certain to have smut in it.

From the very great abundance of spores set free by the broken smut balls, there is much greater danger of spreading this disease, as above suggested, than in the case with oats. This smut of wheat is scarcely at all distributed by the wind but depends upon the above mentioned means for distribution. Such means are so effective that if the disease is introduced and permitted to run its own course, only a few years would be required before it would practically destroy the entire crop.

Preventive Treatment.—It is highly advisable, whenever possible, not to use wheat for seed that is known to contain stinking smut. If wheat known to be clean is not procurable, the smutty wheat should first be thoroughly cleaned with a good fanning mill, using a blast strong enough to blow out the unbroken smut balls even if the lighter sound kernels are blown over also. The spores that are attached to the sound kernels can then be killed without hurting the wheat by treating the grain with a formalin solution in the same way as prescribed for oats. To prevent reinoculation with smut after such treatment, the same methods should be used as with oats.

Stinking smut can be eradicated in at least two years by carefully treating the seed wheat and always guarding against all possible sources of reinoculation. The threshing machine is really one of the most important sources to watch, and the greater the co-operation between neighbors using the same machine the better. If this or some other source of possible inoculation can not always be entirely avoided, it is advisable to clean the grain well and apply the formalin treatment carefully and thoroughly before using for seed.

Treatment With Copper Sulphate or Bluestone Solution.—This method was first used in Europe over one hundred years ago for seed treatment to prevent smut. It is especially applicable for stinking smut of wheat. As shown by this department, it tends to injure, somewhat, the germination and early growth of oats.

In general there are two methods of applying this treatment: either soaking the seed in a strong solution for a short time or soaking the seed in a weak solution for a long time. Either method is effective. The former has been more generally used because the seed does not become so water-soaked. This treatment consists in soaking the seed grain for five minutes in a solution of one pound of copper sulphate to each gallon of water. The treatment with the weaker solution requires the soaking of the seed grain for about 12 hours in a solution of one pound of copper sulphate to each 25 gallons of water. Any gradations of time and strength of solution between these extremes might be used; the object always being to kill the smut spores without endangering the vitality of the grain.

After treatment the grain should be drained and dried as rapidly as possible.

It has been found that after the copper sulphate treatment, dipping the grain for a few moments in lime water is advantageous. Such lime water is made by slaking two pounds of good lime and adding 20 gallons of water.

Hot Water Treatment.—This treatment was introduced by Jensen, a Danish investigator, and enlarged and modified in this country. This department has given extensive careful study to this particular subject. The treatment is used with much success under careful manipulation. It has special merit in treating oats, as it very effectively kills the smut and at the same time accelerates germination and early growth as shown by early studies of this department. It is most conveniently used where steam is available for heating the water. (Care should be taken to avoid letting live steam come in contact with the grain, as this would kill the seed.)

The treatment consists in soaking the seed grain in hot water for a certain time, after which the grain is spread out to dry. The time of treatment varies with the temperature of the water, which, for success and safety, must be within certain limits: 132° to 140° F. for oats; 132° to 135° F. for wheat. The higher temperatures, uniformly kept, require five minutes soaking of the seed, the lower temperature requires 10 minutes, with corresponding gradations between. If the temperature is somewhat higher than the maximum for a brief portion of the time, no harm will result.

A paragraph from Bulletin No. 35, page 86, summarizes the best method to follow in practice. It is as follows: Now it is difficult to maintain a uniform temperature for even so short a time as five minutes. The method to be pursued, therefore, is to place the seed in water at 140° to 145°, and allow the temperature to drop as it will, so long as it does not fall below 130°. If, however, it should by accident drop below 130°, the time must be extended over five minutes. After each quantity of seed is treated, the water is brought up to the required temperature again, ready for the next application. This was written for the treatment of oats, consequently for wheat the 140° maximum temperature should be used. The well cleaned grain may be handled in gunny sacks, loosely filled. These should be kept stirred about in the liberal supply of hot water so as to insure uniform treatment throughout. The water should always be kept well mixed so as to insure a uniform temperature throughout.

Sar* treatment as given in the U. S. Department of Agriculture Farmers' Bulletin No. 250, where it is recommended for wheat treatment, as follows: Sar solution is made by mixing 15 pounds of flowers of sulphur with one-half pound of powdered resin, wetting with about 6½ quarts of water to a thick paste, then adding 10 pounds of dry powdered caustic soda (concentrated lye), stirring vigorously while the whole mass turns reddish brown and boils violently. Enough hot water is added to bring the solution up to 6 gal-

*The word sar was adopted as a short name for this fungicide, being coined from the first letter in each of the words sulphur, alkali and resin.

lons. This stock solution is preserved in tightly corked jugs and must be shaken well before being used.

The seed wheat is treated with sar solution as follows: either 1 quart of the solution is diluted with 50 gallons of water and the grain soaked therein for about twelve hours, or else a strong solution (1 gallon of the stock to 50 gallons of water) is used and the grain soaked only two hours. In either case the grain must be stirred several times during the treatment and spread out to dry afterwards. If the grain contains much smut it should first be washed with water in order to skim off the smut balls before it is put in the sar solution to soak.

The Loose Smuts of Wheat and Barley.—The loose smuts of wheat and barley are similar to each other and consequently require similar treatments. They destroy practically the entire head, changing kernels and glumes to a mass of odorless black spores. These are blown about by the wind at the flowering time of these crops and infect the young sound kernels. In this way these diseases are carried over from one year to the next.

The formalin treatment as recommended in this circular for other smuts of wheat and oats can not be used with success to prevent the loose smuts of wheat and barley; nor is the copper sulphate method, or the Jensen hot water treatment successful. A modified hot water treatment has been tried with some success and is recommended in a recent bulletin of the U. S. Department of Agriculture, Bureau of Plant Industry (Bulletin No. 152). This method deserves a fair trial, especially since these smuts are sources of heavy losses with these crops and very difficult otherwise to prevent. It is hoped that this modified hot water treatment will prove efficient and practicable. Briefly the treatment recommended, as given in the summary of the above cited publication, is as follows: For barley, a soaking in cold water for five hours, followed by a soaking in hot water for fifteen minutes at a temperature of 52° C. (125.6° F.); for wheat, a soaking in cold water for five hours, followed by a soaking in hot water for ten minutes at a temperature of 54° C. (129.2° F.). (See that bulletin for further details of the process.)—(Ind. E. S. Cir. 22.)

Powdery Mildew of Wheat.—The powdery mildew of wheat may be recognized by the white or greyish mould which appears on the surface of the leaves or among the glumes of the fruiting head. It is found to be most serious in damp spots in the field, or in protected or shaded localities. In a field bounded on the east side by timber land it was very abundant, particularly along the edge of the woods. It was also found abundant wherever the wheat is of particularly rank growth.

This disease is caused by a parasitic fungus, the mycelium of which grows on the surface of the wheat plant, sending feeding branches into the surface cells of the host and absorbing its juices. It reproduces itself during the summer by the production of chains of colorless spores which are cut off successively from upright threads of the surface mycelium. These spores serve to spread the fungus from plant to plant and from field to field during the growing season. Another sort of spore is formed later, which being resistant, serves to carry the fungus over the winter. These spores are borne in minute sacks in the interior of a globose, or flattened, receptacle called the perithecium.

This disease is ordinarily of little importance, but under certain weather conditions may do considerable damage. Wet land should be avoided, and care should be taken to avoid wind-breaks on the south or east side of the field. Any condition favoring the retention of dew on the leaves longer than is usual will favor the development of this fungus.—(Del. E. S. B. 83.)

The Rusts of Grain.—While the smuts of grains inflict great losses upon the farmers of the country, they can be controlled by careful methods, and the losses, in most cases, reduced to a minimum. With the rusts, however, it is a very different matter, for they have so far defied all fungicides, whether applied directly to the seed or in the character of sprays. Another point about the rusts is that they work much more insidiously. They manifest themselves in more limited fruiting-areas on their hosts, do not directly attack the kernels of grain, or even the heads, and are consequently neglected by the most of our farmers or entirely misunderstood. Any farmer sees that the smuts destroy his grain while on the stalk, and just so far detract from his yield. Few of them on the other hand realize that the rusts, which manifest themselves in little yellow, red, or black spots on the culms and leaves of the grains, are just as surely sapping the vigor and detracting from the yield of his crop as if they took the grain itself for their places of reproduction instead of the stems and leaves. And it is remarkable how little attention is paid in many places to those little plunderers. Rusts are very common in Idaho, and it is doubted whether a section of wheat can be found that is not more or less affected. If they are so common, how can they best be combatted?—(Idaho E. S. B. 11.)

Some of the treatments used are the following, when a field has shown abundant rust:

1. Let it lie fallow for a year, or, where such is possible, put it into some other crop than a cereal. One year's cultivation will kill out all the spores remaining on the ground, as will a year's summer fallow if all volunteer wheat is plowed under.

2. If such fallow land is not to be plowed, then pasture closely to keep down any vegetation upon which the rusts can get a hold. They flourish nearly equally well on grasses.

3. Where the person cannot afford to summer-fallow land, if such a state of affairs be admitted, and a cereal must be followed next year by a cereal, burn over the stubble, burn all piles of infected straw (as they will infect the field, and are unfit for food for stock), and haul out upon the farm no poorly-rotted and therefore possibly smutted or rusted straw.

4. All wheats suffer from rust, but the early ripening ones suffer least; therefore where rust is abundant plant early varieties.

Protected Trees on Right, Unprotected on Left, from Attacks of Brown Tail Moth and Gipsy Moth. Dept. of Agr.

5. The varieties with straight, stiff leaves are affected less than those which have weak foliage; and the varieties which have thick skinned leaves, or whose leaves are either smooth, allowing no holding-place for the spores, or very hairy, holding the spores but at such a distance from the leaves that they fail to germinate, or germinating fail to infect the leaves, are the best to plant.

6. Don't sow wheat on stubble-land, where rust has been abundant, for the stubble is often black with winter spores, or is capable under certain conditions of lasting green and thus allowing a place of development to the Uredospores.

7. It seems that the red wheats are least affected, while the white varieties, notably Velvet Chaff, are most subject to rust.

8. Poor drainage and an excess of nitrogen in the soil seem also to aggravate the evil.—(Idaho E. S. B. 11.)

DISEASES OF STAPLE PRODUCTS.

BEET DISEASES.

Leaf Spot of the Beet.—This disease is one of very wide distribution. It has long been known both in this country and in Europe, and it probably occurs in all regions where beets are grown even to a limited extent. It is a well-known disease of the red garden beet, but many of the garden varieties are so resistant that the disease is not there a matter of great concern. Observations in New York state indicate that it is much more injurious to sugar beets than to the red varieties. For this reason it needs to be brought to the special attention of those interested in the culture of sugar beets.

The name well denotes the appearance of the disease, at least in the early stages. It begins as small brown spots with a reddish purple margin, these spots being scattered irregularly over the leaf. The spots become ashen gray at the centers, with the border as before; and they may become so numerous as to cover a large portion of the surface of the leaf before there is any general discoloration of the blade. In time, however, the blade shows a parched appearance, begins to blacken gradually from the distal portions towards the stalk, and finally the whole leaf is black and crisp. As soon as the leaves begin to appear parched and dry, they stand more nearly upright on the crown, and a whole field badly affected with this disease makes a very characteristic appearance. The individual blades that are badly affected are somewhat curled or rolled.—(Cornell E. S. B. 163.)

The outer or older leaves are of course first affected, and after the leaf stalks wilt these leaves are shed. In the meantime the plant is endeavoring to supply this deficiency of leaves by continuing to develop new ones from the center, or from the bud. In consequence of this, the crown becomes considerably elongated. If this elongation is very marked, the roots are abnormally small, and much of the energy of the plant is evidently directed to saving itself. Even where the leaves are much less injured, it is undoubtedly a matter of economy to resort to preventive measures.

Sorauer has stated that the leaf spot fungus is not confined to the leaves, that it is also to be found upon the bracts and peduncles of the flowers, and even upon the seed pods themselves. For this reason he thinks that the disease may be transmitted through the seed so as to be in readiness to affect young seedlings. Treatment of this disease, and a successful remedy seems to be at hand in the well-known Bordeaux mixture. Numerous fungicides were experimented upon, but the Bordeaux mixture has proved most efficient.

There is every reason to believe that by beginning the sprayings early the leaf-spot may be almost entirely prevented by the use of this fungicide. If the disease continues so disastrous as it was in certain sections during the past season, for success growers must expect to spray their beets with the same regularity as has been found necessary in growing potatoes.

In general, even the strong solutions of copper sulfate gave slightly better results than the water; and germination was often slightly hastened. In a preliminary test, the germination was very markedly in favor of the copper treated seed; but since the conditions were abnormally close and moist, the exclusion of bacteria by the copper solution might have caused the apparently excessive benefit.

It remains to be determined, however, if it is desirable to treat the seed for the prevention of the leaf-spot.—(Cornell E. S. B. 163.)

Beet Scab.—The smooth surface of the beet root may often be disfigured by warty or scabby excrescences. The texture of these injuries is somewhat corky or spongy, and the larger diseased areas will show that the injury is not entirely superficial, but to some extent alters the tissues immediately underlying such areas. The disease begins as small irregularities either widely scattered or clustered. Individual ones spread in extent, and groups often become united, so that in time it may spread over large areas, or small isolated areas may remain. One often notices a tendency for the scabby spots to be arranged in more or less definite bands, often just at the surface of the ground. The diseased bands, or areas, may, however, appear much lower. It is very probable that this is determined by soil and moisture conditions. The scabby protuberances are abnormal developments of corky tissue stimulated to excessive growth by the presence of the fungus. Professor Arthur has noted sunken scabby spots on the surface of the beet, and he explains these as early injuries which failed to develop further, when the conditions were probably unfavorable, and future growth of the beet has left them rather as pits than as excrescences.

In 1890 Professor Thaxter discovered that potato scab is caused by the growth on the surface of the tuber of a fungus which he named *Oospora scabies.* When scabby potatoes are placed in a moist chamber, a light, grayish, mould-like growth of the fungus may appear on the surface; and it was by inoculations with pure cultures of this fungus that he was able to reproduce the disease on healthy tubers.

In 1891 Professor Bolley found the scab of beets abundantly, and the microscopic evidence which he obtained indicated that the fungus was the same in both cases. He furthermore ascertained that in all cases when the beet scab was abundant, potatoes had been grown on the soil, either the previous year or somewhat earlier. Working independently, at about the same time, Professor Arthur came to similar conclusions about the identity of these two forms of scab; and a single decisive experiment in the transfer of scab from potato to beet was reported by him. Since that time there has been abundant general evidence to establish the fact that scabby beets may be expected if the seed are sown on land which has recently produced scabby potatoes.

The remedy cannot consist in this instance in the treatment of the seed, since the seed do not disseminate the disease; nor can it consist in the treatment of the land, since the experiments with liming, sulfuring, etc., have not given satisfactory results. The only course open, then, is the one of avoiding for the growth of beets any soil which, during several years previous, has produced scabby beets.—(Cornell E. S. B. 163.)

Root-Rot of Beets.—Under favorable conditions for its spread, this beet root-rot generally secures its first foothold at the bases of the leaves. These parts are moist with the slightest rain or dew, and inoculation experiments show that in those regions the disease takes very readily. The first evidence of the attack is manifest in the blackening of these leaf bases, the outer leaves first, so that the stalks soon become unable longer to support the blades, and the leaves may lie prostrate on the ground. The leaves do not, however, lose their green color very readily.

The disease soon works into the crown and root proper, causing the infested parts to turn brown. With further spread of the fungus in the root region, cracks appear. If the conditions continue to favor the disease, in time the whole top rots away, and the beet gradually disappears. Cold weather or dry conditions may so retard the disease that plants only slightly affected may recover entirely.

Even when the bases of the leaves alone are affected, upon careful examination one will find that there are to be seen the brown mycelial threads of the fungus growing over the surface. After the root has become affected, a considerable weft of the fungus will be evident in the cracks. A diseased beet sliced lengthwise and placed in a moist chamber yields in a day or two a luxuriant growth of the mould-like hyphæ.

The use of lime as a possible preventive for certain rhizoctonial diseases has been recommended. The use of an alkali as a preventive might be logically suggested knowing the avidity with which the fungus grows on acidulated nutrient media. The failure of the *Rhizoctonia* to cause trouble in those parts of the field where coal ashes had been used abundantly again suggests the same remedy. Furthermore, Mr. F. C. Stewart has determined that a small amount of alkalinity is fatal to the growth of the *Rhizoctonia* of carnations in cultures. In general it seems that the soils of the State are usually in need of liming, and where this beet disease appears it would be very well to make an application of lime. Sixty to seventy bushels of air-slaked lime per acre would be a cheap and effective means of securing the desired alkalinity. It would be preferable to make this application in the autumn, or at least before the ground is turned, so that the lime would be well distributed.—(N. Y. [Cornell] E. S. B. 163.)

SUGAR CANE DISEASES.

The Red Rot of Sugar Cane.—This is a disease which is pretty widely distributed in the tropical sugar countries at present, it being known in Java, India, Hawaii, Madagascar, West Indies, and probably in other countries. In places, in certain years, it causes a very large loss. At present also, the trouble seems to be quite widely distributed in the southern United States. I have found it in eight parishes in Louisiana during the past year. Specimens from Cairo, Georgia, where the trouble seems to be causing considerable damage have been seen. It is also present and doing considerable damage in at least two counties of northern Florida. The specimens which were received from southern Louisiana during the past spring have shown the disease to be quite severe in places and to be responsible for part of the poor stands during the season.

The disease is caused by one of the small imperfect fungi, known to botanists as *Colletotrichum falcatum.* The fungus does not usually fruit profusely in nature, though occasionally the fruiting pustules may be found on dead parts of the plant or in lesions on the main stem. The fruit pustules appear to the naked eye as very small black specks.

The red rot disease is not easily recognized in a field of growing cane for the reason that the disease is almost entirely on the inside of the stalk. The exterior of the cane may look perfectly normal, while the interior may be badly diseased. Where the disease is very severe, the leaves may turn yellow and wilt; but it is hardly probable that we will find this condition at present in Louisiana. However, in cane that has been planted or windrowed, the disease may develop so well that it will show on the outside of the cane. Many of the eyes will be dead, and there will be black dead areas extending out from the nodes. There may also be somewhat sunken dead lesions on the stalks, especially on the upper joints.

However, the disease is best told by splitting the stalk and examining for the characteristic red color of the tissue. The whole inside of the stalk will not be red, but the color will be more or less irregularly distributed, the red being usually in streaks or bands extending out from the nodal region. There are also frequently white spots surrounded by the red tissue. These white spots are local centers of growth of the fungus. A microscopical examination of these spots will show the cells of the host plant to be crowded full of the mycelium of the fungus. In badly diseased stalks, there are strips also of brown tissue, generally just beneath the rind. Often also the pith of the cane will split, leaving a cavity which becomes filled with the mycelium of the fungus.

The presence of red rot in cane that has first been attacked by borers cannot be so readily told. Borer attack alone will cause a reddening of the tissue. This red, however, is usually intensified if the red rot is also present. Frequently in this cane also, the disease may be diagnosed by the presence of the white spots. But to make absolutely certain as to the presence of red rot in borer cane, cultures from the diseased tissues must be made or else the split canes be placed in a moist place and the fungus allowed to develop on the cut surface. The fungus frequently gains entrance to the cane through borer holes, but these openings do not appear to be essential.

The damage which is done by the red rot occurs in two forms. Canes that are affected with the disease have the sugar content, especially the sucrose, very much decreased. As the value of the crop depends upon the amount of sugar in the stalks, the decrease due to the disease becomes very important. Analyses that have been made in Java, Bengal and the Hawaiian Islands show that the saccharose content is decreased by from 1/4 to 1/3 by the action of the fungus. Consequently a severe attack of the disease means a big loss to the crop. The fungus grows in the stalks that are to be used for planting and kills the eyes, thus preventing germination and causing a poor stand. This seems to be the worse of the two injuries at present in Louisiana. But a poor stand means a short crop with no profits.

The treatment of the disease should be conducted in two ways —*First,* all material in the field known to be diseased should be destroyed, and, *Second,* the cane to be used for planting should be as carefully selected as possible. As the fungus does not fruit to a very great extent, it does not spread very fast in the field. If perfectly healthy canes were planted each time, the disease would cause but little damage. However, when diseased cane is planted, the disease spreads upwards into the young stalks and the eradication of the trouble is impossible. The most desirable thing would be to select carefully all the cane to be used for planting, throwing out any that show any external signs of disease or any that are attacked by borers. This method of selection would, however, hardly be profitable on account of the large amount of time it would take to select the seed.—(La. E. S. B. 120.)

The Pineapple Disease of Cane.—The pineapple disease is perhaps the most serious of all the sugar cane diseases. The trouble is widely distributed in all the sugar-growing countries of the tropics and in all cases does a large amount of damage. Previous to this, however, we have not had the disease to contend with in Louisiana, as it has now just appeared in the state. It is not known to occur in any other state, and is only known to be present in one parish in Louisiana. But there is a strong likelihood of it developing rapidly and spreading to other parts of the state. The presence of this disease in the state is indeed a very serious matter. Of course, there is a small chance that the fungus will not be able to stand our winters and therefore will be of little economic importance, but such good luck as this can hardly be hoped for. The wisest course for the Louisiana sugar planter is to be prepared for the worst and be prepared to take such measures as are possible for the control of the trouble and for preventing its spread.

The disease is caused by another one of the small imperfect fungi, known to botanists as *Thielaviopsis ethaceticus.* The fungus is an extremely rapid growing one and forms spores in abundance. Two kinds of spores are produced. There are first some small linear to oval, hyaline to brown ones which are produced inside the hyphal threads and are pushed out in chains. These are called the micro-conidia. These develop very abundantly on cut surfaces of affected sugar cane stalks, and perhaps also to some extent imbedded in the tissue of the host plant. These spores are blown around to other cane by the wind or are carried by insects. They germinate at the first opportunity and if they are in contact with another stalk produce the disease in it.

Then the fungus produces some larger, thick-walled, dark-colored spores, called the macro-conidia. These are borne in chains at the end of the conidiophores, but they are not borne within the fungus threads, as are the micro-conidia. These serve as resting spores. According to Cobb, they do not germinate immediately, but seem to need a period of rest. If a diseased cane is split, in the matter of a day or so, the cut surface will become black in color, due to the abundance of these spores.

This disease gains entrance to the stalks of cane entirely through wounds in the rind. These wounds may be due to the injury of insects or they may be the cut ends of the stalks. After the fungus has once gained entrance to the stalk it spreads very rapidly, decomposing the cane tissue and killing the eyes.

A stalk affected with this disease does not usually show on the outside. The exterior of the rind may be perfectly sound in appearance, while the interior may be badly decomposed. On splitting the stalk, however, the disease can usually be told. If the disease has progressed to any extent, the center of the stalk will be more or less decomposed. The sugar-containing cells have been disintegrated, and the fibro-vascular bundles of the central region will be seen to be more or less free. This central cylinder, or pipe, as it is called, is generally nearly black in color. If the disease has not progressed far, however, this black color may not be present, but it will develop in a few hours if the split stalk is left in a moist place, as this black color is due to the presence of the macro-conidia.

Then, if the whole stalk is not as yet affected, there will generally be a sharp boundary between the diseased and the healthy joints. The fungus grows very rapidly through the internodes, but is halted for a time at each node. Of course, the stopping of the fungus by the node is only for a time. It soon is able to pass this point and then rapidly grows through the next internode.

Another characteristic point in regard to this disease is the odor given off by the affected stalks. The odor is described as similar to that of ripe pineapples, and on this account it has received the name of the pineapple disease. The disease does also affect pineapples in the tropics, but it did not get its name from this. The odor is supposed to be due to acetic ether, the same as in the pineapple. However, in all the canes which I have had, the odor could be readily told from that of pineapples. The odor is an ethereal one, sometimes quite strong and penetrating, and is, in fact, very pleasant to the smell.

As the fungus grows in the soil, and is more or less at home there, it is a disease quite difficult to control. In tropical countries, where the fungus is everywhere present in the soil, the only thing that can be done is to treat the seed cane with some fungicide as Bordeaux Mixture, thus prohibiting the entrance of the fungus into the stalk. The disease may be spread into new regions in a number of ways, a few of which are as follows:

There has been considerable exchange of cane by planters during the last few years. This has especially been the case since the introduction of some of the newer and better varieties as D-74. The planters have been desirous of trying the new varieties and have obtained them wherever they could. In the future, the planter should be on his guard in regard to this. He should not obtain cane from other regions unless he is positive that the pineapple disease is not present in the region from which he is obtaining it. If he gets some seed cane from some planter that has the pineapple disease, he can expect nothing else than to plant the pineapple disease on his plantation.

The disease may be carried to the mills in the cane and obtain a foothold in the region adjacent to the mills. If the owner of a mill is in a region where there is no pineapple disease, it would probably be better for him to refuse to take cane that comes from an infected region. Cane grown in an infected region should be ground as near to the place where it was grown as possible.

Insects, doubtless, are important in spreading and increasing the severity of the disease. All means possible should be taken to prevent the insect work. Active measures should be taken against the borers and the *poo-a-pouche.* Furthermore, all sugar cane material in the field should be cleaned up as far as possible, thus reducing the amount of infectious material which a large number of insects might work on. The insects working on this material are liable to carry the spores of the fungi to other plantations and in that way spread the disease. The cleaning up of the fields has already been touched on in the discussion of the rind disease.

After the soil is thoroughly infected with the disease, perhaps the only thing that will insure a good stand of cane is the treatment of the cane with some fungicide. Both the pineapple disease and the rind disease enter the seed through wounds and the cut ends of the stalks. The rind is impervious to the attack of these fungi. The object desired in treating cane cuttings is to thoroughly cover them with some compound that is poisonous to the fungi causing the diseases. For instance, if the cut ends of the stalks are dipped in tar and carbolic acid and then planted, the fungi not being able to grow where these substances are present, will not be able to get to the interior of the stalk. Of course, the dipping of the ends is not practicable on a large scale on account of the expense involved. In order to treat the cane on a large scale and to treat it rapidly, we must have some solution in which the whole stalk can be placed, one which will not kill the eyes of the cane but one which will prevent the attack of the fungi. The only solution which we have at present which approaches this requirement is Bordeaux Mixture. This is a copper-lime compound which is very poisonous to fungi and will not penetrate the eyes of the cane so as to hurt their germination. The treatment of sugar cane cuttings with this solution is not only practicable but is highly profitable in tropical sugar countries. Of course, special machinery and special tanks are used so that a large amount of seed can be run through the solution in a short time. Whether the treatment of the seed would be profitable to the Louisiana planter in normal years is a question, but I am convinced that it would be profitable during a dry season. And if the pineapple disease spreads over the state and does as much damage as it does in the tropics, the treatment of the seed will not only be profitable but it may become a necessity.—(La. E. S. B. 120.)

The Root Rot Disease.—The root rot disease has been well treated in Bulletin 100 of the Louisiana Station and only a few points need be mentioned here. The disease is caused by one of the higher fungi, one of the mushrooms, known to botanists as *Marasmius plicatus.* This disease attacks both the cuttings and the growing cane. On the growing cane, it kills the roots and grows in between the lower leaf sheaths. The leaf sheaths are not shed as is the case with healthy cane, but remain glued together around the stalk. If some of these are pulled apart, a network of white mycelium will be seen between them. In August, or perhaps during others seasons, if the weather conditions are suitable, the little mushrooms, the fruiting part of the fungus, develop on these leaf sheaths.

On the cane which is used for seed, this disease will also develop. I have seen it to some extent in nearly every batch of cane which has been sent me this year. The mycelium enters the cut ends of the stalks and grows through them. The disease is readily told by the presence of the white strands of mycelium which may be on or in the stalks. Sometimes the eye is killed before germination, and sometimes the young plant is killed after germination.

This disease is widely distributed in the state and probably has been for a long time. In some places it does considerable damage, but in normal years the loss has not been large. This year it has caused considerable loss both in the plant cane and in the stubble. The dry weather has put the cane in a more or less unhealthy condition and the cane has been very susceptible to the disease.

Other Cane Rots.—While the fungi causing the four diseases previously discussed were the most frequent and the most prominent in the cane cuttings that were received, there were some other organisms present which undoubtedly rotted some of the cane and should be studied further. As it is the intention of the station to continue the study of the sugar cane diseases, the study of these will be taken up as time permits.

Summary.—During the past season the sugar planters of Louisiana have had considerable trouble in obtaining good stands of cane. The investigations of the experiment station have shown the trouble to be due primarily to several fungous diseases. These diseases have been much more severe this year than in previous years on account of the very dry spring. The dry weather reduced the vitality of the cane and made it more susceptible to the diseases. The diseases present in the state are the red rot, the rind disease, the pineapple disease, and the root rot. The red rot, rind disease, and root rot are widely distributed over the state, but the pineapple disease is at present only known in one parish.—(La. E. S. B. 120.)

COTTON DISEASES.

Root-Knot, Root-Galls, Root Nematodes.—Only a few cases of root-knot of cotton in this state have been brought to my attention, yet I am loath to believe that it is not quite common, especially on thin sandy soil and worn out lands. Cotton growers are probably more ignorant of the presence of this disease in their fields than any other. This is likely the true explanation of the lack of satisfactory information on the distribution of this trouble throughout the state. Mr. Orton, of the Department of Agriculture, has found that root-knot of cotton is often associated with wilt. Root-knot so weakens the root system that it affords easy or favorable conditions for the entrance of the wilt fungus. Many weeds and cultivated plants are subject to this trouble. One of our best soil renovators, the cowpea, is very susceptible. It is bad economy to follow diseased cowpeas with cotton.

Root-knot is a disease that attacks the roots or underground parts of the cotton plants. All cotton plants suffering from root-knot are dwarfed. When the roots are badly diseased, the plant suffers a lack of food and water, wilts and finally dies. A plant may not show any striking symptoms but on examining the roots the cause of the disease can be easily determined. They are covered with warts, galls or excrescences of various sizes and shapes, and sometimes are as large as an inch in diameter. When the affected roots begin to die they send out new roots so that before long the root system becomes bushy and tangled.

This root affection is due to a microscopic worm about 1/60 to 1/20 of an inch long. It burrows into the root, thus setting up an irritation which later produces these wart-like excrescences or knots. If these knots are numerous the nutrition of the plant is interfered with. It becomes enfeebled and finally dies.

No treatment of diseased roots with poisons, is practicable since the amount necessary to kill the worm would also seriously injure the root. Carbon bisulphide, arsenic and kerosene emulsions have been tried without success. Alkaline fertilizers such as kainit, potash, and lime have been mentioned as good checking agents. Allowing the land to go fallow for two seasons has resulted in almost ridding the soil of the worm. This method is expensive and unnecessary since there are crops that can be grown on land containing the root-knot organism without receiving any injury. Wheat, oats and rye are examples of such crops. Clean cultivation which would rid the soil of infected weeds and diseased crops would be of great value in retarding the spread. The best means of control rest in a proper system of rotation, using crops that are not susceptible, and in this way starving out the nematodes.

Texas Root-Rot.—The first indication is a sudden wilting followed by the death of the plant in most cases. The disease usually appears about the latter part of June or the first of July though it can be found at an earlier date and even when the plant is more mature. On pulling up the plant and examining the roots closely a further indication of disease can be noted. The diseased roots are covered with dirty yellowish filaments of the fungus which causes the trouble. Sometimes numerous scars are visible on the roots. The smaller roots are dead and dried up.

This disease is attributed to the work of a parasitic fungus which lives in the ground and rapidly spreads throughout the soil. It can enter the roots through wounds, but is perfectly able to penetrate healthy roots. Its strands or mycelia plug up the water conducting vessels and cut off the water and food supply. This fungus remains in the root and unlike the wilt fungus does not extend into the stem.

Deep plowing, together with a proper system of rotation seems at present to be the only adequate means of checking this disease. Mr. Shear, of the Department of Agriculture, advises fall plowing at a depth of 7 to 9 inches. In addition to this he advises a two or three year rotation with grasses or grains. The deep plowing aerates the soil to quite a depth and offers unfavorable conditions for the development of the fungus which thrives better in a compact soil that lacks air. That this work may be properly done, the cotton mule and ordinary plow will have to be replaced by heavy animals and 12 to 14 inch plows.

Cotton Leaf Blight.—This disease is very common on cotton. It is found on the less vigorous or old leaves. It is likely to attack all the leaves of weak plants if the soil is wet and the climatic conditions favorable for the development of the fungus. This trouble affects the leaves by producing spots upon them. These spots are red at first, grow larger centrifugally and later turn brown. Sometimes the centers of these spots are white. This is the case when the spores are abundant. In the last stages of disease the leaves are ragged and full of holes. The fungus *Cercospora Gossypina* is the direct cause of this leaf blight. The strand or filaments are found within the plant while the fruiting bodies or spores are produced on the surface.

Cotton Rust.—Black rust, yellow leaf blight and mosaic disease are classed under the general term of rust. They are merely different names for the same malady.

This disease affects the leaves. The first indication of trouble is shown in the yellow mottled appearance of the leaf. The yellow portions are farthest away from the source of food supply, the veins. These latter stay green for a longer time. Being deprived to a great extent of the means of sustenance the leaf in a weakened condition becomes a prey to various fungi which ultimately destroy it. The leaves fall off and sometimes the stalk is entirely bare. Such plants do not set a top crop as a rule and therefore the yield is seriously reduced. The lint is often badly damaged being shorter and inferior in quality.

The disease is due to unfavorable soil and weather conditions. Thrifty and vigorous plants do not suffer until the food supply is withdrawn. The three important factors to which rust is attributed are (1) lack of humus, (2) lack of potash, and (3) lack of drainage. Heavy rains followed by long droughts cause no injury to the cotton plant if the soil is in a condition of proper tilth and fertility. Let these conditions be reversed and serious outbreaks of rust will follow. Diseases of this class are all called physiological, since they are responsible for the constant interruption of the normal development of the plant.—(Miss E. S. B. 140 B.)

The remedy for rust lies in changing the unfavorable soil conditions and in securing conditions that will support a vigorous growth of the plant. When land has been cropped to cotton for a long term of years it lacks humus or decaying vegetable matter. This kind of soil needs building up and can be done by plowing in a green crop. A crop of cowpeas or beans are especially good. Barnyard manure is beneficial and will do much to prevent rust. Kainit or potash at the rate of 200 pounds per acre will do equally as well as barnyard manure if the latter is not available. Better drainage of wet lands and seepy hillsides will also reduce rust.

Damping-off or Sore-Shin.—The young plants first show signs of weakness in the stem near the surface of the ground. The turgid cells lose the water they contain and become flabby. At this point the stems bend and the plants fall to the ground. Quite often the plants are only partially affected. This is true of the older plants. One side is marred by a canker or ulcerous depression. Unless these diseased spots interfere seriously with the normal functions of the plant, the latter will partially recover but will never be normal.

The sterile fungus, *Rhizoctonia,* is usually considered the cause of this trouble. Its natural habitat is the soil. The disease is sometimes due to the anthracnose fungus or other parasites. Such damping-off disease must be clearly distinguished from wilting due to dry soil or dry air. If warm favorable weather prevails, the cotton seedling may outgrow the disease. As the sterile fungus prefers acid soils, and alkaline soils are fatal to its growth it would follow that the addition of lime to the soil would be exceedingly beneficial.

Shedding of Bolls.—Squares, forms and young cotton bolls often fall for other causes than that due to the injury by insects. Not all of the shedding can be attributed to the boll worm or weevil. In many instances no fungus or insect can be found on or in the affected parts. Such shedding is simply an outward manifestation of improper or faulty nutrition and assimilation. The disease is a physiological one. Climatic conditions have much to do with the presence or absence of this trouble. It is quite common in either very dry or very wet weather. It is also present during the change from one extreme to the opposite. If the plants are crowded and the growth rank, sufficient food is not available to supply all fruit forms especially those furthest from the source of supply, consequently many squares fall.

Some varieties of cotton seem to be more susceptible than others. Certain soil conditions have a detrimental influence and aggravate this trouble. Even the character of the fertilizer is said to show a marked effect on shedding. During some seasons the loss by this disease is considerable. Under normal conditions there is also a loss which, however, does not reach an alarming stage.

The symptoms are easily recognized. The parts affected change in color from a deep green to a pale green and finally become yellow. In the majority of cases the forms drop off, yet it is not uncommon to find some attached to the parent plant by a few strands of the peduncle or stalk.

This disease is a physiological one and cannot be attributed to any one cause. It is rather the result of a series of causes which are constantly changing. Such causes are the unfavorable conditions of climate and soil.

Physiological diseases have as yet received little attention at the hands of plant pathologists and for that reason it is difficult to give any reliable remedy. We have no control over climatic conditions and therefore the hope of a suitable remedy lies in the direction of a thorough study of soil conditions. A system of soil preparation, culture and fertilization with a view to affording the best conditions for the development of the plant should do much towards checking this malady.—(Miss. E. S. B. 140 B.)

Cotton Wilt.—The cotton plant is subject to wilt at an early date. When about ten or twelve inches high, it is susceptible and from then on to maturity. Wilt is most abundant in June and July, especially when the rainfall is plentiful in early spring and during the growing season.

The external characteristics are first apparent when the leaves turn yellow at their margins and between the veins. Later the whole leaf becomes yellow and drops off. In extreme cases of wilt nothing but the bare cotton stalks and branches are left. In less severe cases one or two branches may be stripped of leaves while the rest of the plant is apparently unaffected. Wilted plants may partially recover but will always show a stunted or bushy appearance.

It is by means of the internal appearance of the affected cotton stalk that we establish without a doubt the cause of this disease. The wood in the region of the water conducting vessels that pass up the root and stem is brown. When the stem is cut across with a knife this brown ring is clearly seen and is due to the dense, closely woven threads or hyphæ of the fungus which has filled up the vessels, shut off the water supply and killed the plant. This brown ring in the stem is characteristic of this disease. In addition to the above symptoms the tap root of a wilted plant is shorter, and the lateral roots less abundant.

This disease is due to a microscopic plant, a fungus which goes by the name of *Neocosmospora Vasinfecta.* It is found in an actively growing state in the soil existing on decaying organic matter. The soil then is its original home or habitat and in this place its existence is that of a saprophyte. But when it enters the root and stem of a cotton plant it changes its nature and becomes parasitic.

Cotton wilt cannot be controlled by spraying with fungicides for the cause of the trouble is found within the plant. The soil, which is the natural habitat of the fungus, has been treated in various ways with poisonous substances. None of these solutions have as yet proven efficient. On the other hand they have not only proved impracticable but expensive.

It has been suggested that the soil can be freed from this disease through a system of rotation, yet data have been collected to show that this takes from seven to ten years and the results are not as promising as one would expect. Deprived of cotton as a source of food the fungus still continues living by subsisting on decaying matter and so prolonging its life as a saprophyte for a term of years. Wilt gradually diminishes when the land is put into rotation but is not entirely eradicated for the period of time mentioned above. The destruction in the fall of all diseased plants lessens in a measure the spread of this disease. At the same time it kills the boll weevil and other injurious insects, and keeps the land in better sanitary condition.

The most efficient method of control lies in the use of resistant varieties that can develop well and reach maturity in spite of the adverse soil conditions—wilt infected soil. These wilt resistant forms have been produced by breeding and selection. Mr. Orton of the Department of Agriculture has produced resistant varieties from both the upland cotton and the Sea Island cotton. Those of the Upland variety are the Dillon and the Dixie. Those of the Sea Island are the Rivers and the Centerville. The farmers that have wilt sick land should by all means plant seed raised from wilt resistant varieties.

Anthracnose.—The condition of the weather has much to do with the amount of anthracnose. A very dry season hinders the development of the spores and affords a natural means of checking the spread of this disease. On the other hand a wet season creates the most suitable conditions for its development and spread. So little is known about this disease that we are not yet in position to give a complete discussion.

Anthracnose, pink boll, or boll rot is determined primarily from external characteristics. It is most destructive as a boll disease, yet it also injures the stem, leaf and cotyledons of young seedlings. The first indication of trouble on the boll is shown in the appearance of small reddish brown spots, which grow larger and become depressed in the tissues of the boll. Soon the spores develop and occupy the centers of these spots. Climatic conditions are responsible for the abundance or scarcity of these spores. If the conditions have been favorable, large quantities of spores are produced and the pink color is very apparent, otherwise they are scarce and the diseased areas have a grey cast.

A boll which is badly diseased externally upon opening will disclose rotten and badly discolored lint. The lint in partially diseased bolls is inferior and harbors countless pink spores. The greatest damage to the bolls is done before they mature. If attacked near the time of maturity, the normal development is interfered with and an imperfect boll partially diseased is the result. From these half opened, dried bolls the lint is hard to gather and oft times is never touched. The loss of cotton in this way is quite a large item.

This fungus also attacks the stems of young plants near the ground often causing death. The cotyledons are also injured by the fungus which is imbedded in its tissues. Greyish or pinkish spots are found on the weaker leaves. The stem may also show these depressed pink or grey areas so constantly met with on the bolls.

The fungus is an active parasite able to penetrate any portion of the cotton plant and cause disease. Professor Barre's investigations show that the fungus winters over in the seeds which, when germinated in the following spring produces the disease in the seedling or young plant. The spores also winter over in the diseased stems, bolls and seed in the field. Ten months appears to be the length of time they can sustain life under adverse conditions. Much has yet to be learned concerning this serious pest which causes considerable loss throughout the state every year.

Various remedies have been tried, but our knowledge is yet too incomplete to advise any definite remedy. Spraying with fungicides has not proven practical, since this would have to be done when bolls were open, thus spoiling the lint. As infection has been traced to the seed the spray would not reach the center of infection. Treating the seed with poisonous substances has not proven effective. By selecting clean seed from bolls unaffected the disease can in a measure be checked.—(Miss. E. S. B. 140 B.)

FLAX DISEASES.

Flax Wilt.—The plants are attacked at all ages and die early or late in the stage of growth according to the time and intensity of the attack. If the soil is much infected, that is to say flax sick, most of the plants are killed before they get through the surface of the ground. Such areas appear in a field of flax as centers of disease, which enlarge throughout the summer as new plants sicken, wilt, and die down around the margins of the spots, finally giving the whole field a spotted appearance. Young plants, two to five inches in height, wilt suddenly, dry up and soon decay if the weather becomes moist. Older plants which are quite woody take on a sickly, weak, yellowish appearance, wilt at the top, slowly die, turn brown, and dry up. Nearly mature plants which are attacked, but not yet dead, are easily pulled up, the roots breaking off easily at about the level of the furrow slice.

Upon examination, most of the smaller branch roots are found to be dead, as well as the tap root below the point at which it breaks off. These dead roots and the parts of the tap root already diseased have a very characteristic ashen gray color. Many nearly mature plants which are attacked late in life show this dead gray down one side of the tap root only. The leaves, side branches, and a strip of the main stem above this portion are dead, giving a peculiar one sided blighting, similar to the appearance of a tree struck by lightning.

If the disease is sowed with the seed upon breaking, but a few plants are attacked the first year; and, at flowering time, dead plants will be seen to be quite evenly distributed in the drills. If weather conditions are quite favorable, each new infection increases sufficiently in area to reach over and attack plants in two or three adjacent drills. These infection areas are nearly always circular in outline, and become much enlarged if flax is seeded there the following year. The first year these spots may reach a diameter of one to three or four feet. The second year these same areas are usually much more than doubled, so that it takes but three to five flax crops upon such lands to make the infection general.

Because of the peculiar and characteristic manner in which all young plants and the soft parts of more mature ones droop and wilt when attacked, as if through drought or intense heat, it is thought best to call the disease *flax wilt.* Though the trouble may be properly referred to as *flax sick soil,* the term *flax wilt* will prove distinctive.—(N. Dak. E. S. B. 50.)

How to Treat Flax Seed.—There are some difficulties connected with treating flax which are not encountered in handling other grains. When I first recommended the formaldehyde treatment for wheat and oats, a number of farmers complained that it injured their seed. In so far as I have been able to investigate any of those cases, the trouble has been due to some defect in the manner in which they carried out the work. I hope that no farmer will undertake to treat his flax seed until he has read the directions here given very carefully. While the amount of seed to be handled over is much less than in the case of oats and barley, one must do the work very much more carefully. I have only to call attention to the fact that the mere wetting of flax seed, unless it is quickly dried, is injurious to its germinating qualities. One ought, therefore, in treating flax, to be very careful not to use a bit more of the solution than is necessary to dampen the grain. If by accident you should chance to supply more moisture to a batch of seed than you ought to do, throw in some more dry seed at once and stir it over rapidly. The dry seeds will withdraw the excessive moisture from those which are too wet, and thus prevent injury to the latter.

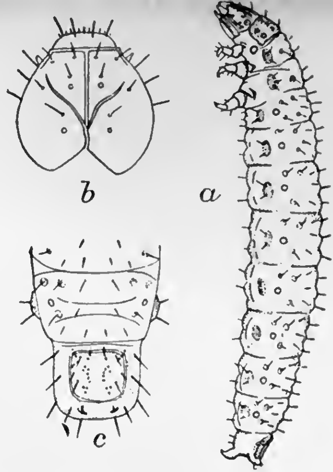
I would not recommend that any one should undertake to treat all his seed flax this year. Try a sufficient amount to sow an area large enough from which to harvest the seed for next year's crop.

By another year you may learn to avoid many errors which might now arise through inexperience.

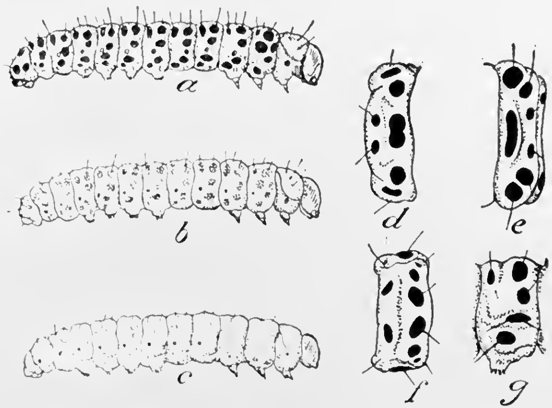
Use formaldehyde at the rate of one pound of the standard strength to forty or forty-five gallons of water (the same strength used for wheat and oats). Spread the seed upon a tight floor or upon a canvas and sprinkle or spray on a small amount of the liquid (a fine spray is best). Shovel, hoe, or rake the grain over rapidly. Repeat this spraying, shoveling, hoeing or raking until the surfaces of all of the seeds are just evenly moist, not wet enough to mat or gum, but evenly damp. (This can be done without matting if the grain is well hoed or shoveled over while the solution is slowly and evenly sprayed upon it). When the seeds are just evenly moist, cease applying the solution, but continue to shovel the grain over so as to get it dry as soon as possible. Avoid any excess of moisture. If flax seeds are dipped in the solution or are allowed to get wet enough to soften the seed coats so that they will stick together, they will be considerably injured or even killed.—(N. D. E. S. B. 50.)

There are also no types of our farm plants which may suffer more harm from the presence of weeds than flax. This alone would be sufficient excuse for thoroughly cleaning the seed before sowing upon the land, but there are other good reasons for doing so. We have found by experiments that the weak, immature, scaly or chaffy seeds are able to carry great numbers of the spores of the wilt disease lodged in the scales or creases. Such seeds are usually soft at threshing time and thus, if spores fall upon them, they become glued to the seed. In one experiment seeds from the screenings taken from a lot of flax seed which was diseased contained a very much greater percentage of flax wilt spores than the plump seed from the same sample. The test showed but two soil infections from 100 of the plump seed taken from the cleaned sample. This sample had been run through the fanning mill but once. The weak, scaly seeds taken from the screenings produced thirty-seven soil infections from one hundred seeds planted. It is thus quite certain that a thorough cleaning and grading of the flax seed would greatly reduce the possibility of infecting new soils with the flax wilt fungus. We earnestly recommend that those who do not think that they have time to treat their seed flax, or are afraid to do so for fear they may, through inexperience, injure the seed, should clean the seed thoroughly. This will remove all weak seeds and tend to cause an even stand of the flax, which is much to be desired, as it is very important in a flax crop that the plants should be of even strength so that they may ripen evenly. The spores of the flax wilt do not seem to be able to cling to good, smooth, plump seeds, unless the flax has been wet or damp at some time. When such good seeds are run through a fanning mill, the loose spores and bits of chaff and dust which carry the disease are blown away.

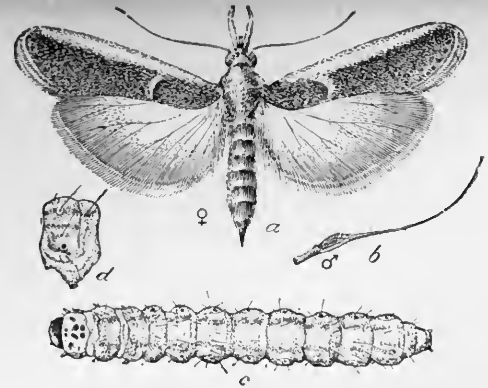
Cautions.—It takes less than one-half gallon of the solution to properly moisten one bushel of flax seed. One must treat flax with much more care than that usually taken in treating wheat or oats for smut. The solution recommended is strong enough to kill all seeds,



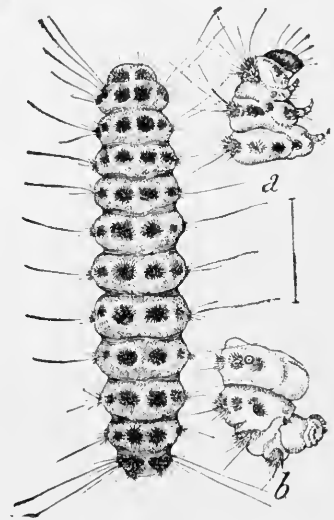
Hop Flea Beetle, (Psylliodes Punctulata.) Dept. of Agr.



Larger Cornstalk Borer. Dept. of Agr. (See page 176.)



Lima-Bean Pod-Borer. Dept. of Agr.



Grape Leaf Skeletonizer; Full Grown Larva. Dept. of Agr.

if they are made thoroughly wet, or if they are allowed to stay quite damp for some hours. *The grain must be handled over immediately after treatment until it is found to be dry. Note:* The seed should be thoroughly cleaned by running through a fanning mill before it is treated because the solution is not strong enough to kill the disease (*fungus*) which is inside of bits of straw and chaff.

Summary With Notes.—1. There is a diseased condition of flax soils which has long been known to farmers in flax producing regions as flax sick soil.

2. If flax is sowed rather continuously for a number of years upon the same soil this disease tends to thoroughly infect the soil so that flax growing becomes no longer profitable.

3. The disease may be spread by way of the seed flax.

4. The plants attacked die at all ages as if attacked by wilt; hence I have called the disease the flax wilt disease.

5. The direct cause is a minute fungus parasite which grows on the inside of the flax plant, starting either from the seed, or by attacking the roots of older plants if the soil has previously been infested.

6. There are many ways in which the infection might reach new fields, but the chief one is by way of the seed.

7. The seed (spores) of the parasite gets into the seed flax at threshing time, rattling off from the sides of the flax straws which have been attacked by the parasite.

8. When such infected flax seed is sown, the spores of the fungus germinate and at once attack the young plants. Those attacked early die at once and there may be no stand even from good seed if the spores of the parasite are abundant. When once in the ground the fungus spreads rapidly, attacking new plants throughout the season. It can live from year to year upon the humus of the soil, hence the soil is soon ruined for flax. Six years of continuous seeding of flax upon the same plot at the Agricultural College thoroughly filled the soil with the parasite and no plants of flax can live there longer than three weeks.

9. All other farm crops do well upon the flax sick soil. It has not lost fertility for flax, as is proved by experiments which destroy the spores without injuring the soil.

10. The fungus belongs to a genus of plants which botanists have called Fusarium. As this is a new species, we shall call it Fusarium lini.

11. Much of the soil of this state has not yet been infected; but about 50 per cent. of all samples of seed flax yet examined show the presence of the Fusarium spores. It is probable that no sample of flax seed is entirely free from infection.

12. When the soil is once infected no way is known to rid it of the parasite. The fungus is able to live in the soil for many years without the presence of a flax crop to feed upon.

13. The seed flax should be thoroughly graded and cleaned in a fanning mill before treating. This will remove all of the bits

of diseased flax straw and chaff which would not be sufficiently treated to kill the fungus inside of them.

14. After treating, it may be well to sow two or three quarts more per acre, as some of the weaker seeds are apt to be killed.

15. Scaly flax seed and seed which has been wet is always very poor for seed. Such seeds harbor the spores of fungi which kill the young plants as soon as the seeds germinate.

16. Cease sowing flax year after year upon the same land. Put at least one cultivated crop and two or more other crops between flax crops.

17. Burn as much of the old flax straw and stubble which remains upon the ground as possible.

18. Raise your own flax seed, grade it up to the best. Watch for diseased areas and notify the station. Thresh your seed, when you can, in your own machine from a patch of strong healthy flax and store it in a clean bin.

19. Keep all the flax straw out of the barnyard, unless it is intended to put all manures through a several years composting process.—(N. Dak. E. S. B. 50.)

SMUTS OF SORGHUM.

Kinds of Sorghum Smuts.—There are in this country two well-known smuts of sorghums: The grain, or kernel, smut (*Sphacelotheca sorghi*) and the head smut (*Sphacelotheca reiliana*). The grain, or kernel, smut is easily distinguished by the fact that only the individual kernels, or grains, are affected, while the head retains its usual form and nearly its usual appearance. Most, if not all, of the kernels in a smutted head are usually destroyed. Each kernel is changed into a more or less conical, grayish to reddish mass containing the dark-colored smut dust, or spores.

The head smut is very different in appearance. The whole head, just as it emerges from the upper leaf, is converted into a single large smut mass, covered by a whitish or grayish membrane, which soon bursts and sets the spores free. In this smut, therefore, all trace of the individual grains, or kernels, is lost. The smut mass resembles somewhat in appearance a smut mass on corn.

It is not yet known how many of the various groups and varieties of sorghum each smut infects. The grain smut occurs on all of the principal groups, while the head smut has been observed on sorgos (sweet sorghums), kafirs, and shallu. Neither smut has been observed on milo up to the present time, and attempts to inoculate milo with the kernel smut of kafirs and sorgos have proved unsuccessful.

Grain, or Kernel, Smut.—Of the two smuts of sorghum, the kernel smut is at present the more widely distributed. It is found almost universally where sorghum crops are grown. The losses sustained are in many districts very severe. They are increasing and will continue to increase unless preventive measures are adopted.

The life history of this grain smut is now well known. It is similar to that of stinking smut, or bunt, of wheat, viz, the spores, or smut dust, get on the kernels in threshing or in handling, and when the seed is planted they grow at the same time that the seed sprouts. The smut plant penetrates the stalk of the young seedling plant and grows inside of the latter until the heads are formed, when the fungus forms its spores inside of the grains, replacing the latter.

As in the bunt of wheat, careful seed treatment will kill the smut spores, because the latter cling to the outside of the seeds, and after such treatment the crop will be free from smut.

It is therefore very important that any farmer who is not sure that his seed is free from smut should treat his seed in one of the ways suggested in this circular. When his seed is once clean he can keep his farm free from smut by raising his own seed, provided he does not allow it to become smutted again in a smutty thrashing machine or in the subsequent handling of the grain.

Treatment of Grain Smut.—Seed that is smutty may be treated in the following ways: Formalin treatment: Mix 1 pound of full-strength formalin with 30 gallons of water. Put the seed in sacks and immerse the sacks in this solution for one hour, stirring it occasionally. Then take the sacks out and set them to drain. Spread the seed out on a clean floor or canvas. Be sure that all of the sacks, the barn floor, and the canvas used in handling the grain after treatment are cleaned either with boiling water or with a strong formalin solution. The seed will be infected again if any untreated smut spores touch it. When the seed is sufficiently dry after treatment it may be sown.

The same solution may also be used as a spray, in which case the seed to be treated should be spread out on a clean floor or canvas and sprinkled with the solution. It must be shoveled over frequently until all of the seeds are wet. It may then be shoveled into a pile and left over night, covered with a clean canvas or sacking to keep in the fumes, and then spread out to dry in the morning. Seed treated in this way will be free from smut. The immersion method is more thorough, but is not as convenient as the sprinkling method.

Hot-Water Treatment.—Hot water is a most cheap and efficient means of treating sorghum seed. The treatment is more easily applied to sorghum than to wheat and barley, because sorghum seeds (at least those of kafirs and sorgos, or sweet sorghums) will stand much higher temperatures than wheat and barley seeds. The smaller quantity of seed used to the acre in the sorghum crops is an additional advantage, making it possible to treat easily all the seed required for a large area. In the hot-water treatments of sorgo and kafir a fairly wide range of temperature is permissible, and the operation is therefore easily performed on the farm.

In brief, the process is as follows: Heat two large vats or tubs of water to about 135° and 140° F., respectively. Place the seed to be treated in a clean sack or wire basket and plunge it into the tub of water heated to 135° F. for a moment. Then transfer the sack to the second tub or vat for ten to twelve minutes. Keep the temperature of the water in the second tub between 134° and 140° F. It should not be allowed to go above 142° or below 134° F. The seed should be frequently stirred in order to keep the temperature uniform throughout. Small sacks should be used, since in large sacks it is impossible to keep the temperature constant. After this treatment the seed is spread out to dry on a clean floor or canvas. When sufficiently dry it may be sown.

As in the formalin treatment, every precaution must be taken to prevent infection of the seed after treatment. Although this treatment is not as convenient as the formalin method, it is just as efficient, is cheaper, and, on account of the wide range of temperature, is easily applied. It is superior to the formalin method in that the farmer does not have to rely on a druggist for the strength of a formalin solution. If the formalin is not of full standard strength (*i. e.,* a 40 per cent. solution), the formalin treatment may not be successful. In the hot-water treatment all of the implements and materials are directly under the control of the farmer.

Copper Sulphate Treatment.—Solutions of copper sulphate (bluestone) also give satisfactory results, but are certainly no better than, and probably not even as good as, the two methods described above.

Head Smut.—At present the head smut does not occur in abundance beyond a very restricted area in the Panhandle of Texas. Its life history is not yet understood, but enough is known to show that the treatments recommended for the grain smut have absolutely no effect upon the head smut. This indicates that this disease may be more difficult to control than the grain smut when once it succeeds in getting a fair start.

The only recommendation that can be made at the present time is to keep the smut away from the farm and the community. In order to do this the farmer must be sure that his seed did not come from a crop that contained head smut. If it is allowed to spread unchecked, it bids fair to become troublesome in the future. In case it is already present on the farm the infected plants should be cut out completely and burned before the smut spores have a chance to scatter.

Recommendations.—The precautions necessary and the proper treatments for the smuts of sorghum crops may be summarized as follows:

(1) If possible, get seed free from smut—from fields that are known to have had no smut during the preceding year. Also be sure that such seed has not become smutted in harvesting and handling.

(2) Keep your farm free from smut by using your own seed and employing only machinery that will not contaminate your crop. These first two precautions will insure you against both kinds of smut.

(3) Treat your seed with either formalin or hot water if you are not sure that it is free from smut. This will not necessarily insure the farm against head smut.

(4) Maintain a quarantine against any locality or farm where smut is known to exist, as well as against any seed grower who allows

smut in his fields. This course will largely prevent the spread of both kinds of smut.

(5) Maintain a quarantine against any handlers of machinery who allow their machinery to become or remain contaminated with smut spores. This would be effective against the grain smut. It would probably have no effect on the head smut, however.

(6) Milo has not yet been reported as subject to either smut, and hence may probably be safely grown without treatment.—(B. P. I. 374; Cir. 8.)

RICE DISEASES.

Rice Blast.—This disease is variously known as *blast, blight* and *rotten-neck.* It is, in all probability, the same as the disease of rice known in Italy as brusone, and in Japan as imotsi. Blast is caused by the attack of a particular species of fungus known as *Piricularia oryzæ.* The most conspicuous lesions are found at the sheath-nodes just above the joints of the stem, at the region where the stem comes to be the axis of the head (the neck region), and at the points where the blades of the upper leaves join their sheaths. The first indication of disease is apt to be a small, pale, somewhat watery spot; this increases in size, passing through shades of brown and finally becomes quite dark. The lesion extends more rapidly in an upward direction; at the neck it may involve as much as two inches of the axis, or it may completely encircle a sheath-node. In the later stages a nodal area frequently shows transverse fissures due to the contraction and cracking of the dead tissues. At the junction of leaf-blade and leaf-sheath there is a breaking, as a result of which the blade hangs downward, it having given indication before this of its general unhealthy condition by a paling of color and drying. At the neck the diseased area is weak, and as the head becomes heavy in maturing, it gives way and the head hangs down or falls to the ground.

The more general effects of blast are seen in the extensive paling and drying of leaf and stem, and in the poor condition of the head. The worst effects on the head are seen when infection of the plant is early and the fungus is well established before the head shoots up from the last leaf-sheath. In such cases none of the grains fill out; and the erect heads with their light colored empty glumes can be distinguished at a distance. Such a condition caused by blast must not be confused with the white blast following the attack of the larvæ of a moth which bore into the straw above the last node and cause the death of the head usually before flowering. The two conditions are somewhat similar in appearance, but are quite different in their nature.

If the attack of *Piricularia* at the neck is later and less severe, the head will fill out to a greater or less extent, but there will always be a considerable proportion of poorly formed grains. Many such heads will break at the weakened neck region while the rice is standing, and many others during harvesting. The circumstance that the heads that break are apt to be the heavier of the affected ones, makes this source of loss especially heavy. In threshing, much of the grain from affected heads is of such light weight as to be blown out in the cleaning. Because the damage caused by blast is apt to appear late, it is a frequent thing for the disease to occasion considerable miscalculation in regard to yield. Up to the heading period and even beyond it, indications may point to a good yield; and there is surprise and disappointment when the number of sacks turns out to be very many fewer than the expectation.

The destructive effects of the rice blast fungus may be seen at times upon quite young plants less than six inches high. The first indications of attack are brown spots which come to have ashy gray centers and involve the whole thickness of the leaf. These spots enlarge and coalesce until practically the entire leaf is involved. The lower and older leaves of the plant suffer first, and become entirely brown and dry and shriveled; afterward the younger leaves are destroyed, and the plant appears dead. But even in such severe cases a small percentage of the plants may have the closely wrapped bud portion unaffected, and under proper conditions may send up new shoots and continue growing. This blight of young rice seems to be infrequent, but it may be quite destructive when it does occur.

Spotting caused by *Piricularia* may occur on the leaves of plants almost or quite mature; but in such situations the effects are localized, and there is no such general dying as follows leaf infection of quite young plants.

Preventive Measures.—1. In the South Carolina experiments it was found that spraying with Bordeaux mixture while the heads are still in barrel prevented serious damage from blast. Unfortunately the spraying of rice at such a stage is not a practicable measure. It is interesting to note that this treatment has been recommended for brusone in Italy; the efficacy of it would tend to support the contention that brusone is due primarily to the attacks of a parasitic organism rather than to a condition of the root system.

2. In the Carolina experiments it was found that applications of lime to the soil reduced blast and greatly increased yields. While this treatment seemed at first quite promising, further tests under a wider range of conditions have not been altogether satisfactory, and lime is not to be recommended as a general preventive of blast.

3. The idea has prevailed in some quarters that the withdrawal of water at the time of heading up will prevent blast. Insofar as the writer has been able to learn the experience of rice growers in this matter, the evidence is rather conflicting. As has been indicated already, the whole matter of the treatment of rice at about this period, and for that matter at all periods, ought to have careful study with the purpose of determining the relation to the spread of blast.

4. Immune varieties. It is of interest to know that the variety of rice known as bertone in Italy was, at the time of its introduction into that country in 1828, almost if not absolutely immune to brusone. But in the years that have followed bertone rice has lost to a great extent its resisting powers, and at the same time there has been marked general deterioration in the variety. Nevertheless this gives indication that it may be possible to discover or to originate varieties

of rice having satisfactory resistance to blast. Proper care ought to maintain the excellence of such varieties.—(La. E. S. B. 105.)

Black Smut of Rice.—The interior of an affected grain is filled with a dry black powder which is enclosed for a time in the grayish outer membrane or cuticle. Often there is a slight enlargement of the grain, and the glumes are separated a little so that a portion of the affected kernel is exposed to view; but sometimes the grain is not enlarged. When ripe, the thin dry enclosing membrane is readily broken, and the black powder scattered, leaving the glumes empty except for the remnant of the membrane. Some of the powder adheres to the outside of the glumes, giving them a black color, and it is by this appearance that affected grains are most readily detected in the field, they being otherwise rather inconspicuous. But frequently the glumes of sound grains are black, either from spores of black smut reaching them from nearby affected grains, or from the growth on them of the dark mycelium of another and saprophytic fungus. The presence of the black powder filling the seed is the distinctive indication of black smut.—(La E. S. B. 105.)

Treatment of Smutted Rice.—Until we have succeeded in germinating the spores of rice smut, and have learned how infection of rice plants takes place it will be impossible to say definitely just what fungicide or treatment will be most effective as a remedy. What seems to be the mycelium of this fungus has been found by the botanist in the tissues of rice culmus. Rice grains are affected in a manner similar to that in which wheat is affected by the stinking smut. Spores are found adhering to the husks of the seed. The smut appears to be closely related to stinking wheat smut. The spores in the seeds may not be the ones through which infection of rice seedlings takes place. This infection may result from spores remaining in the soil. It seems probable, however, that the smutty grains, and the spores on the seeds are instrumental in infection. In this case these spores should be destroyed. There are effective remedies for stinking wheat smut, and it seems probable that the remedies for wheat smut will be found useful here.

We have shown that the potassium sulphide treatment may be safely employed; indeed, that it has a tonic effect upon the seedlings. Likewise, that copper sulphate (½ per cent. solution) is safe though not as desirable as the potassium treatment, and that the seed may be scalded three seconds with advantage, and soaked 24 hours in a ½ per cent. solution of formalin without material injury, while ¼ per cent. solution has been found by others sufficient in the treatment of stinking wheat smut. Without positive evidence, we believe that any of these treatments would destroy the spores of rice smut. This we hope to find out. That the reader may try them we give several treatments which have been found effective in the treatment of the above mentioned wheat smut.

Before giving the several fungicidal treatments I wish to call particular attention to the method of separating smutted and other light rice grains from the good and heavier seeds. Not only may a large number of smut spores be destroyed in this way, but the process is attended with another advantage. During recent years experimenters have frequently shown that the largest and heavier seeds of various plants produce the best plants and crops. A marked gain results from selecting such seeds. He who would improve his varieties and crops must practice selection. It is the plant breeders magic wand. It is not enough that we select out the fittest among plants, but we should carry the principle of selection to the very source—the seeds from which plants spring. By floating out weak and smutted rice seeds, as below described, and using only the heavy and healthy, we will be applying this useful principle to our rice crop.

If rice seed in the husk be poured into cold water and stirred about, all good seed sink after a few seconds. Smutted, light or defective grains remain floating. These may then be skimmed off and burned. This treatment answers of course only for rice "paddy," or in the husk.

Dissolve one and a half pounds of potassium sulphide or liver of sulphur (fused) in twenty-five gallons of water in a barrel or other wooden vessel. Add now three bushels of the seed to be treated and stir thoroughly so as to wet every grain. The whole should then be left standing twenty-four hours, when the liquid should be strained off and the grain spread out to dry. This solution may be used over for three lots of seed if used immediately, but the solution of potassium sulphide does not keep. The grain should be spread out to dry in as thin a layer as practicable in order to dry readily. If it is to be sown at once, however, thorough drying will not be necessary.

Some experimenters recommend soaking the seed a shorter time in a stronger solution because the grain is afterward easier to dry. If this method be followed a 2 per cent. solution of potassium sulphid (8 pounds to 50 gallons of water) may be used. In this the grain should be left two hours, and the seed treated otherwise as above.

Seeds may be immersed for a few seconds in scalding water for the destruction of smut spores, but only for a few seconds, otherwise the embryo will be injured or killed. A safer plan is to immerse them for a longer time in water at a lower temperature. This is the plan which is ordinarily followed.

For this treatment two large vessels holding each some twenty gallons at least are necessary. One of these should contain water at a temperature of 110 degrees to 120 degrees (Fahrenheit); and the other water at a temperature of 132 degrees to 133 degrees, F. The second vessel should contain as much water as will equal in bulk five or six times that of the seed to be treated. It will then be more easily kept at the proper temperature, which is as near as possible to 133 degrees, F. Besides these vessels two others with a supply of cold and boiling water should be conveniently at hand to be used in maintaining the required temperature of the hot water bath.

The seed to be treated are first placed (a half bushel or more at a time) in a bag of loosely woven material or sacking, or else in a basket of wire netting. Plunge it then first into the vessel containing the water at 110 degrees to 120 degrees. Lift it, and when it has drained a moment plunge it into the vessel with water at 133 degrees. After a moment lift it, allowing most of the water to drain out. Then replunge it, and repeat several times, making sure every grain is wet with the hot water. If the water is maintained at a temperature of 133 degrees the seed may remain in the bath ten minutes, which will kill the spores without injuring the seed. Should the temperature rise to 135 degrees the seed should not be kept in the water over five minutes.

The nearer the temperature is kept to 133 degrees Fahrenheit the better will be the results. Below this the spores are not so likely to be killed. Above 135 degrees the seeds may be injured, unless the immersion is very brief. The gauging of temperature should be done with a reliable thermometer. The sack or wire basket should be amply large so that seed while being treated may move above.

If a quantity of seed is to be treated two persons should be on hand, one to handle the grain, the other to maintain the proper temperature of the water, by adding hot or cold water from time to time as may be necessary. That the temperature may be uniform the water should always be stirred whenever hot or cold water is added. If steam is available a small pipe running into the hot water vessel will make it comparatively easy to maintain the proper temperature.

After treatment seed should be spread out on a clean floor in an airy place in a layer not thicker than three inches, or it may be placed upon sheets resting on a lattice frame a foot or so above the ground. To facilitate drying, grain spread out upon the floor should be shoveled over two or three times a day. If thoroughly dried, seed may be treated some months in advance of sowing. If to be sown immediately they need not be so thoroughly dried.

After treatment care will be needed to avoid reinfection. The seed should not be placed in any vessel or on any surface likely to contain spores of smut, or where smutted grain has been before. Tools or vessels likely to have spores on them may be disinfected by dipping them in scalding water. The floor where the rice is to be spread may be previously disinfected by washing with a strong solution of copper sulphate.

Other Treatments.—Formalin (a 40 per cent. solution in water of formaldehyde gas) has been found to be an effective remedy for smuts. It is used at the rate of 1 part to 50 or 60 gallons of water. The seed should be soaked in this solution two hours and otherwise managed as in previous treatments. The dilute solution is not poisonous. The material should be purchased full strength.

Copper sulphate (blue stone) 1 pound in 24 gallons of water is effective as a treatment for smut. The grain should be soaked in this solution 12 hours, after which it should be soaked in lime water for 5 minutes. It should then be drained and dried as in other treatments. The lime water is to be made by slacking 1 pound of lime and then diluting it with water to 10 gallons.—(S. Car. E. S. B. 41.)

TOBACCO DISEASES.

The Mosaic Disease of Tobacco.—The mosaic disease, or Frenching, of tobacco, locally known in Connecticut as calico, is one of unusual interest. The diseased plants exhibit such a mottled appearance of the leaves, due to the alternating areas of darker green and yellowish green in them, as to make the appearance of the plants very striking. The leaves are veritable mosaics; as such they catch and hold the interest of the observer. Certain plants will exhibit these characteristics and color markings while others near them have the normal, uniform green color. In the tobacco field, as most will recall, plants with abnormal color are quite frequent in unfavorable soil situations and especially around wet areas. This class of situations is however by no means the only one; no particular specifications may be made to apply generally in this respect. The mosaic disease occurs in practically all tobacco areas of this state and of the United States and under favorable soil conditions; indeed the disease is general throughout the tobacco growing districts of Europe and Asia as well. Along with the mottled, or mosaic appearance of the leaves we may have distortions of the leaves due to the unequal rate of expansion in the more healthy and in the diseased areas of the leaves.—(Ohio E. S. B. 156.)

Possibly no other type of plant disease has so long resisted the efforts of investigators to discover the cause producing it. It seems now that we must class the mosaic disease of tobacco, the yellows of the peach, peach rosette, the mosaic disease of tomatoes and the mosaic disease of forcing house cucumbers, which the writer has recently investigated at Ashtabula, Ohio, in one and the same group of maladies. To discover the actual cause, or causes of these diseases has long been the aim of students of plant pathology. In recent years decided progress appears to have been made; but as yet the final word is to be said on this matter of cause. Mayer early made a careful study of the disease. He showed that the disease is transmitted by inoculation and concluded that it must be the work of bacteria. In 1898 Beijerinck made a decided contribution. He showed that the juice of diseased plants, filtered through porcelain filters, yet retained the power of producing the disease when a small drop of it was injected into a growing bud of a healthy plant; he also found that diseased tissue kept these infectious qualities even after drying and retained its injurious properties in the soil during the winter; he further demonstrated that the soil around the roots of diseased plants may affect the roots of healthy plants. Studies of the disease have been made in our country by Sturgis and by Woods. The last named publication will be of very great value to any one who wishes to study the conditions surrounding the production of the mosaic disease in tobacco. Just as in a sense Beijerinck was the discoverer of what he called a living fluid contagium which he regarded as the cause of the disease, Woods was able to go further and ascertain the presence of certain enzyms in the plants known as oxidizing ferments and named *oxidase* and *peroxidase*. Both these investigators were able to transmit the disease by inoculation of fluid from diseased plants into the young portions of healthy plants. The difference between the results of the one and the other is in the specific designation by Woods of the oxidizing enzym as the active agent in producing the disease.

Nature of Root-Rot.—During the past few years a disease known as root-rot has made its appearance in the tobacco fields in some districts of Kentucky, Connecticut, Ohio, and Wisconsin. This disease is now generally recognized to be due to a soil fungus *(Thielavia basicola)*, which attacks the feeding roots of the tobacco as fast as they are thrown out. The root-rot generally makes its first appearance in the field in spots, particularly low spots, and may later develop throughout the field. The most striking feature is the failure of the plants to make a proper growth. The diseased plants are often only 8 or 10 inches high when healthy plants set at the same time are ready to be cut. These small plants will be found to have only a small ball of stubby roots, and the fungus can be seen on the blackened or brownish ends of the roots, which in the active stages of the disease have a rotted appearance.

Root-rot has already been successfully checked in the seed-bed by Selby with the use of formalin, and by Shamel through sterilization by steam. Neither of these methods can be considered practicable for treating the disease in the field.—(B. P. I. Cir. 7.)

The object of this circular is to give briefly the preliminary results to overcome the attacks of this fungus on the tobacco in the field by the proper use of fertilizers, with the hope that the suggestions offered can be utilized this season by tobacco growers who have fields affected with this disease. The results of the writer's investigations thus far indicate that the tobacco is much more severely injured by the fungus on fields where the soil has been made alkaline by the long-continued use of large amounts of lime, ashes, and fertilizers containing carbonate of potash. The remedy for diseased soils appears, then, to consist in avoiding the use of lime and in applying the necessary potash in the form of the sulphate of potash, which is a neutral salt; and, if the field is badly diseased, in applying the phosphoric acid in the form of acid phosphate in order to help neutralize the alkalinity of the soil. The above view as to the cause of the development of the disease in some of the tobacco fields of Connecticut is in harmony with field observations, as will appear in the following pages.

The Granville Tobacco Wilt.—The first indication of the disease is given through the leaves which droop, becoming soft and flabby as though suffering from want of water. This symptom is not accompanied by any change in color; the leaves remaining green for some time after the wilt appears. As a rule the lower leaves droop first, the wilting gradually proceeding from the ground upward. Frequently the leaves on one side of the plant succumb earlier than those on the other side. Some growers believe that one side of the plant may occasionally survive to maturity, though the other side be wilted, but that is not usual. Frequently even a single leaf will show one-sided infection. The wilted leaves soon die, dry up and eventually the whole stalk dies. It then remains standing with its dead leaves still hanging. It is thus not to be confounded with temporary wilting due to lack of moisture, excessive heat, etc.

At the stage of earliest wilting a section across the stem shows a yellowish discoloration of the woody portion. In more advanced stages, or in sections taken lower on the stem, the wood is found either on its inner or outer parts to be penetrated longitudinally by black streaks, varying in size from that of a cambric needle to that of a knitting needle. These streaks are so abundant in stages immediately preceding death that the whole or nearly all of the wood seems to be so affected. Frequently similar streaks penetrate the pith, though this is only in the most extreme cases. The black streaks in the wood are usually more abundant adjacent to the cambium than to the pith, and simply removing the bark from near the base of sick plants, discloses them in abundance. The blackening often progresses from the wood outward through the bark, producing shrunken, blackened patches on the surface of the stem.

In more advanced stages when all the leaves are wilting the wood and bark at the base of the plant are blackened nearly throughout and the pith has decayed leaving the stem hollow or filled with a soft, rotten residue. The bark near the level of the ground turns black, and becomes dry and hard. The pith and wood in the upper portions of the plant usually dry up before decay overtakes them resulting in the collapse of the upper portions of the plant in irregular longitudinal folds in parts where the woody layer is too soft to maintain the shape of the plant when the support of the distended pith is withdrawn. If a badly diseased plant be cut off near the ground, a dirty yellowish exudate issues from the cut wood, accumulating in a layer one or two millimetres thick. This exudate is slightly viscous, hanging together in strands two to four millimetres long when picked with a knife point.

The root seems to be the seat of the original infection, and any plant in a stage of disease advanced enough to show symptoms in its foliage will be found to possess roots already in an advanced stage of decay. In early stages one root or more may be diseased; in later stages all succumb; in the more advanced stages of disease in any root the bark is black, soft and dry, a spongy mass of fibre left by the decay of the more watery parts. In the worst cases even this spongy covering may drop off leaving the wood of the root bare and dry. Usually, however, the bark remains as a spongy layer, surrounded by a dry papery jacket more or less cracked transversely, the remains of the epidermis. The decay is characteristically a dry one, although if the soil be wet with rain the decayed residue may become slimy, wet, and mushy.

The wood of the root undergoes changes similar to those of the stem. In the root as in the stem the disease manifests itself earlier in the wood than in the bark, appearing first as longitudinal streaks of black, in that portion of the woody cylinder lying close to the bark. The disease is most conspicuous in the largest roots, but the smallest fibres, upon close examination, are seen to be similarly affected. In cases where the woody cylinder is blackened before the adjacent bark shows injury the smaller feeding roots, which pass from the diseased wood through the still healthy bark die. They are infected by or they infect the wood of the central cylinder.

When all the roots of a plant are diseased death is naturally more rapid than when a few only are affected, and in such cases the progress of the decay of the stem is cut off by the death of the plant. Thus in the plants most badly diseased the disease does not reach as high as in plants less affected. The wood midway up or near the top of such plants shows no blackening, barely a slight yellowish tinge is evident.—(N. C. E. S. B. 188.)

Spread of the Disease.—Corroborative evidence from tobacco growers seems to establish definitely that this disease increases in violence upon a given field year by year after the first infection. In the first year of its occurrence in a field, a few plants only may be affected. The next year that tobacco follows on this field larger regions are affected. A third year without protracted rest from tobacco growing would probably in every case bring on deplorable conditions.

The germs grow and multiply in the affected plants. Upon the death and disintegration of the plant they are liberated in the soil where they seem to be able to live for considerable time. The immensity of their number in a diseased plant furnishes inconceivable hosts, so that even a few diseased stems, roots, or leaves in the field will stock the soil plentifully with the germs. Infected plants or soil in which infected plants have been or which bears parts of infected plants, can therefore convey the disease to healthy fields.

Instances have been cited in previous pages where the contagion has been spread by WASHING from higher land to lower, so, too, may it be carried by any means which can convey soil from a sick to a healthy field, notably through TOOLS, which have been used on diseased soil. Though apparently reasonably clean, such tools, if they bear even a fraction of a spoonful of infected soil, may carry hundreds of germs and thus start an epidemic in the field next cultivated. The HOOFS of animals or the FEET of laborers, may in a similar way bear the disease-laden soil. WIND passing over an infected field may pick up broken bits of sick tobacco plants or germ-laden soil, and convey these to healthy fields. Infection by wind, however, seems to be rare, possibly because of the germicidal action of the sun's rays upon the surface layer of soil upon which the wind must act. It is still an unanswered question whether the germ can live through the heat of the curing-house. If it can, an additional means of dispersal obtains in the manure made from the refuse stalks and stems derived from such plants.

It is hopeless to attempt to cure a plant after it is once diseased. Prevention must be relied upon. With the knowledge that the disease is caused by living germs rational methods may be adopted to prevent its spread. Any means which can carry soil from a diseased field to a healthy field may spread the disease. One of these ways is by washing. In some cases a field now healthy may be protected from higher land that is infected by proper arrangement of dykes.

A second means of soil conveyance is by tools. A cultivator or a hoe used in an affected field carries myriads of germs. If such a hoe be used in an unaffected field these germs will be distributed and the disease spread. This means of spreading is largely within the control of the farmer. All that is required is such thorough cleansing of tools that no possibility of conveying the germs remains. First, the dirt should be knocked off, then wiped off and the implement finally cleaned by being thoroughly wet with a solution consisting of two per cent formalin or five per cent carbolic acid. It is difficult to insure complete protection against spread by the feet of animals and man, but every possible precaution should be exercised in this particular.

Every diseased plant is veritable culture ground for the germs. Therefore every such plant and every part of such a plant should be destroyed by fire. Pull the plants up by the roots, getting all of the roots possible. Let them dry and then burn them. This precaution in a badly diseased field diminishes the nourishment at the disposal of the germs and will probably enable the land to recover more rapidly. Burning is, however, especially important where but a few plants in a field are affected. Prompt action here may materially lessen the rapidity of spread of the disease in the field. It should be borne in mind that every particle of sick plant burned means the destruction of millions of the germs.—(N. C. E. S. B. 188.)

The germs reside in the soil. The possibility of killing them in the soil therefore arises. Experience with other diseases which in a similar way winter in the soil leads to but slight hope that any method of soil sterilization will ever be practicable. This germ is different from others that have been experimented upon, however, and the importance of the problem demands that a thorough trial be made.

The fact that the seed-bed seldom if ever bears diseased plants indicates that the heat generated by burning the bed, suffices to kill the germs.

A long rotation of crops, one that will bring tobacco back upon the affected field only after an intervening period of several years, perhaps after a period of eight or ten years, seems at present to be the only recourse for one whose field is now infected. Even with this precaution it is doubtful whether the disease can be completely eradicated.

The tobacco wilt germ has not been proved to be injurious to other crops, and tobacco-sick soil can probably be safely planted with any other crop, with the possible exception of such close relatives of the tobacco as the Irish potato and the tomato and egg-plant.

A Wilt Resistant Kind of Tobacco.—The one means of overcoming the wilt which is most promising to farmers who own affected soil lies in the discovery of some variety of tobacco that will not wilt even when planted upon sick soil. Varieties of cotton that can resist the cotton wilt, and of cow peas that can resist the cow-pea wilt have been discovered. There is similar hope in regard to the tobacco wilt. If several plants grow under the same conditions in infected soil and one of them survive while the others wilt, this survival may be due to a special resistance on the part of the plant which prevents the encroachment of the parasite. Such a plant should be caused to seed, and its seeds saved with great care, since this ability to resist the disease is a character that may be transmitted to the plant's offspring. Seeds from resistant plants should be tested on sick soil, and any plants that prove resistant should again be saved as seed plants. A few years of such selection of seed from resistant plants may result in the development of a race of wilt-resistant tobacco similar to the wilt-resistant cotton and cow peas, which were developed in a similar manner.—(N. Car. E. S. B. 188.)

DISEASES OF FLOWERS.

BEGONIA.

Nematodes.—These minute worm parasites attack the roots and also the leaves of cultivated begonias. For the commoner root injury avoidance is to be sought in the preparation of the earth.

Root-Rot.—The root-rot fungus of violets and tobacco *(Thielavia basicola)* was found attacking the roots of begonia which suffered from nematodes. Its general occurrence since the discovery upon tobacco and catalpa show that it is capable of serious injury to the roots of these cultivated plants.—(Ohio E. S. B. 214.)

CARNATIONS.

Carnation Disease.—It generally starts in the leaf when immature, and is best diagnosed in the younger but full-sized leaves nearest the upper end of the stem. Taking such a leaf, which on its surface presents no unusual appearance to the eye, and holding it toward a strong light, small, pellucid dots may be detected scattered irregularly through the leaf, sometimes having a faint yellowish color, which are the centers of infection. The appearance of the dots has a close resemblance to those of the oil glands in the leaves of the common St. John's wort *(Hypericum perforatum)*, a rather abundant weed, or in the leaves of the false indigo *(Amorpha fruticosa)*, a native shrub, except that they have no regular disposition. Sometimes the surface of the leaf is slightly raised over the dots, making watery pimples.

After a time the surface of the leaf above the dots changes enough to indicate their presence and finally shows a distinct spot. As the disease extends inside the leaf the surface tissues dry, the internal tissues collapse, and whitish, sunken spots appear. In some colored varieties of carnation the spots vary somewhat by being more or less reddish or purplish. As the spots increase in size the leaves wither, still clinging to the stem. Such spots never show distinct central darker-colored specks and rarely any concentric circles, as do the spots made by parasitic fungi, such as Septoria (spot disease) and Heterosporium (fairy ring).

Very badly diseased plants, especially when much crowded and growing in damp atmosphere, have more yellowish green leaves than normal, of a more transparent appearance, and usually smaller. The lower leaves of diseased plants in any atmosphere or soil die prematurely and the vitality of the plant is so lowered as to check the growth and decrease the size and number of the flowers. —(Purdue E. S. B. 69.)

That aphides and not bacteria are responsible for the trouble is shown by the fact that the injuries produced are not accompanied in the earlier stages by fungi or bacteria. The aphides therefore can not be looked upon as simply carriers of some fungus or bacterium, as they produced the disease on plants growing under perfectly antiseptic conditions as quickly as upon those not protected by antiseptics.

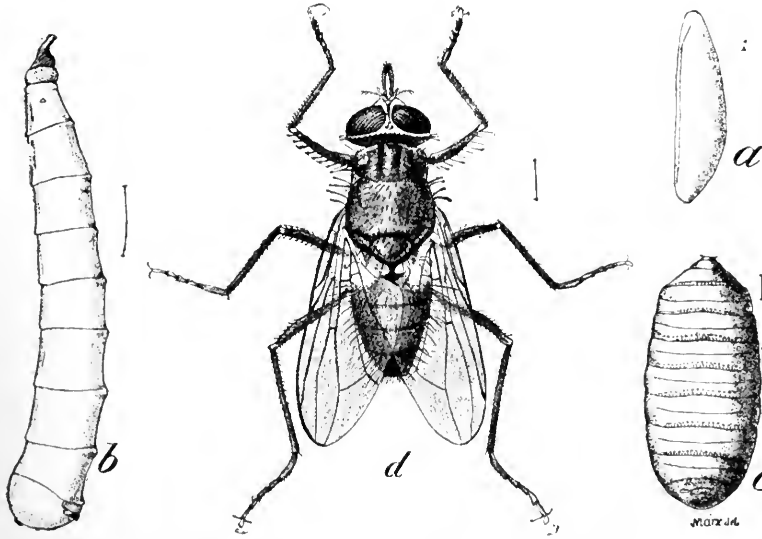
Injuries similar in many respects to those produced by aphides also result from the attacks of thrips—insects which are often present on carnations growing under glass, although sometimes overlooked by growers. Another form of the disease is produced by red spiders.

No matter how badly diseased plants may be, if otherwise vigorous they will grow out of the disease entirely and the young leaves and shoots will remain free from spots if kept completely free from aphides, thrips, and red spiders.

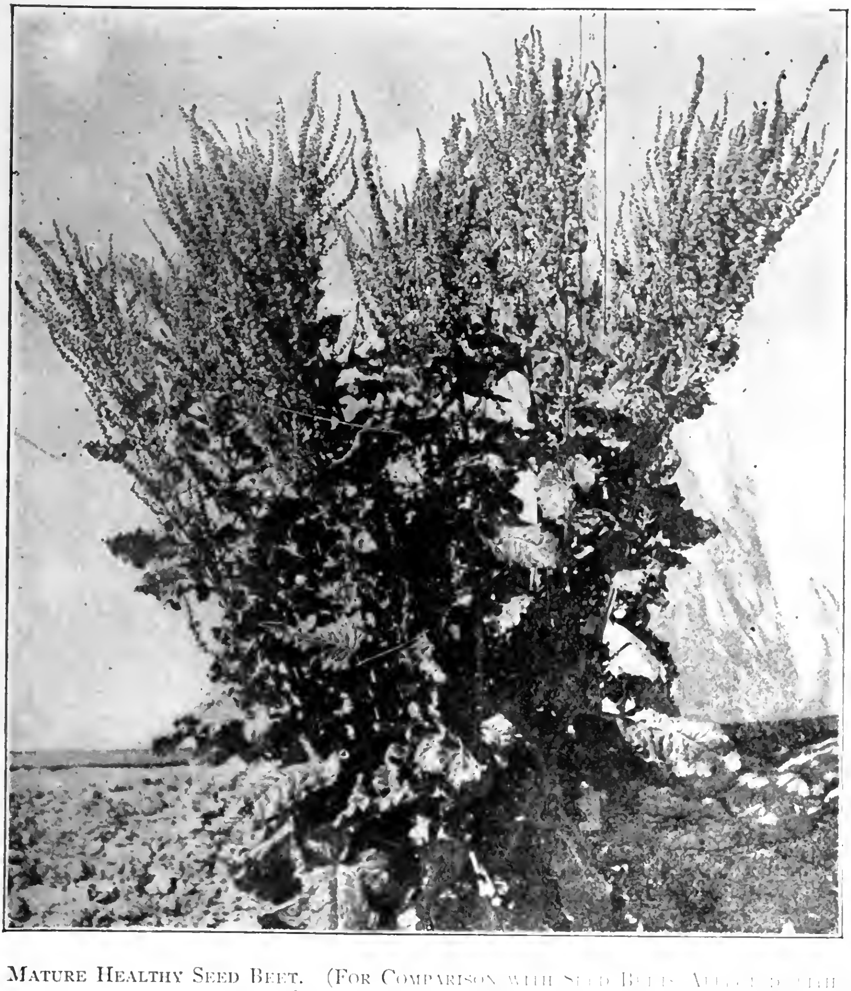
Treatment.—The grower can successfully combat this disease by the proper selection of cuttings; careful propagation of stock; good soil; the proper amount of moisture, light, and air; and by the reduction of aphides, thrips, and red spiders to a minimum.—(U. S. Div. Veg. Path. B. 19.)

Bud-Rot.—The bud-rot of carnations produces effects which show externally, the character depending upon the extent and severity of the infection. The most striking external symptom is the failure of the affected buds to expand into perfect flowers. Carnation benches in which the bud-rot is prevalent generally show a considerable number of flowers that will never open completely. Sometimes the affected flowers deviate only slightly from the normal. Flowers which have a split calyx may resemble these superficially in the unfolding of the petals. In buds in which the infection is more severe or begins at an earlier date, the petals become only slightly expanded and the buds die without ever developing into perfect flowers. If such affected flowers are not picked off, the projecting portions of the petals wither and turn brown and the calyx soon dies also, and assumes a brown coloration. In a few cases the buds are apparently infected at a very early stage, for the calyx does not open sufficiently to allow any projection of the petals, but turns brown and dries up.—(Nebraska E. S. B. 103.)

All affected buds show upon closer examination that all or part of the flower parts included within the calyx are affected with a rot which has caused a brown coloration and a softening of the tissues.



HORN FLY. DEPT. OF AGR.



MATURE HEALTHY SEED BEET. (FOR COMPARISON WITH SEED BEETS AFFECTED WITH CURLY-TOP.) DEPT. OF AGR.

In some cases the spaces between petals show a whitish hyphal growth plainly evident to the eye, while in other cases no hyphae can be detected without a microscopic examination. When affected buds are broken open, oblong watery-looking objects, 1/12 inch or less in length, are found buried in the soft mass of rotting petals or lying between them. These objects are the distended abdomens of minute female mites, which have been found as constant accompaniments of the fungus. In the earlier stages of the rot in natural infections the mites may be quite small and inconspicuous, but in well-developed cases of bud-rot they are so evident that they could not be easily overlooked.

The work which has been carried out up to the present time leads to the conclusion that the disease can be prevented or eradicated if the following measures are carefully heeded:

1. Practice clean culture with the destruction of all refuse that might offer a temporary lodging place for either fungi or mites.

2. Keep the moisture down to the minimum necessary for the healthy growth of the plants.

3. Pick off all affected buds as soon as they appear and destroy by *burning*. Do not under any conditions throw them down on the benches. The benches should be gone over at least every other day until the disease is thoroughly under control.—(Neb. E. S. B. 103.)

Leaf and Calyx Mold (Fairy Ring).—This is often very unsightly upon the calyces and pedicels of these flowers; it also attacks the leaves. All sorts appear to be more or less parasitized with the fungus in the houses where it prevails. Yet another spotting is produced by the carnation leaf-spot fungus *(Septori Dianthi)*, which has appeared at this Station more frequently upon the Daybreak variety. It is believed that both these fungi will yield to treatment with Bordeaux mixture as per calendar.

Carnation Rust.—This rust fungus is one of the serious diseases of the carnation. There is some difference in the liability of varieties to the disease, and perhaps a much larger difference in the condition of the stock plants from which cuttings are made. Assuredly this matter of cutting stock is of very great importance and one admitting of selection of the very best plants. Experiments conducted at this Station in 1896 yielded no gain from spraying with Fowler's solution, which has been sometimes recommended. Watchfulness in the destruction of rusted parts, and in the stock for propagation, are suggested for the control of rust.

A Root- or Stem-Rot.—This has been noted by Stewart, and occasional rotting of the flowers through the presence of a Botrytis. For the former no thoroughly effective remedy is now at hand, while general cleanliness of the house is necessary to avoid the rot fungus Botrytis.

CANNA.

Rust.—Foliage of canna is sometimes attacked by a rust which may be identified by the characters of its fungus *(Uredo cannae)*.—(Ohio E. S. B. 214.)

CHRYSANTHEMUMS.

Chrysanthemum Rust.—The rust is easily distinguished from all other diseases that attack the chrysanthemum. It forms small blisters, about the size of a pin head, or by coalescing much larger ones, which appear on the under surface of the leaf, and to some extent on the upper surface. These soon break open and expose a dark brown powder, the uredospores. On badly infested plants the leaves are well covered, especially beneath, with the loose brown powder, indicating the wonderful possibilities in spreading the infection to healthy plants in the vicinity, as every grain of this powder is capable of starting the fungus in a growing leaf, if the conditions are favorable.—(Ind. E. S. B. 85.)

Having carefully reviewed the present knowledge of the characters and habits of the fungus, only a few words will be required to outline the treatment for its suppression or control. Care should be taken that the rust does not invade an establishment. All purchased cuttings or plants should be carefully looked over for the rust, and also closely watched for at least a month afterward to detect the very beginning of the disease, should it develop. If taken in time, removing the diseased leaves as they appear, and burning them without scattering the spore powder, is likely to stop its spread. Other precautions which will occur to any cultivator, like wholly destroying very badly infested plants, may also be employed. Should it continue to crop out in spite of all such attention, every leaf and stem above ground should be destroyed at the end of the flowering period, and the young plants or cuttings for the next season's supply be grown in an uncontaminated house and if possible from uncontaminated material. With an understanding of the nature of the rust fungus there will probably be little difficulty in fully eradicating the disease by the end of the second season at the longest.

Spraying with a suitable fungicide to keep the rust in check has been recommended by a number of writers. How efficient this method will prove cannot be definitely stated, as experimental reports are lacking and the Station has not had an opportunity to make tests. The Bordeaux mixture may be used, or sulfide of potassium. For the latter, use one ounce to two gallons of water, and apply weekly. No fungicide is likely to stop the disease without hand picking, but if rightly used will undoubtedly prove a material assistance.—(Ind. E. S. B. 85.)

Leaf-Spot.—This is frequently a disfiguring disease of this plant in earlier growth. It is caused by the leaf-spot fungus *(Septoria Chrysanthemi)*. Two other fungi, a *Phyllostica* and a *Cylindrosporium,* also attack the chrysanthemum. For indoor treatment copper sulphate solution of one fourth of the strength given in the spray calendar—that is one pound to 50 gallons of water—will prove available. More applications will be required, but the foliage will not be rendered so unsightly as with Bordeaux mixture which, however, may be applied in full strength.

Powdery Mildew.—Powdery mildew also occurs upon chrysanthemum foliage. The fungus *(Erysiphe Cichoracearum)* is usually not persistent, but calls for spraying foliage with fungicides when serious.

Ray Blight.—A blight of the rays of chrysanthemum flowers due to a specific fungus *(Ascochyta chrysanthemi)* is reported from the south and is very liable to be present in Ohio.

CROCUS.

Root-Rot.—Little study has been made with us of the diseases of bulbous plants, yet we are liable to import those occurring in Europe. The common root infesting fungus, *Rhizoctonia,* is one of the determined troubles of crocus in France. Microscopic identification of the trouble should be easy owing to the characters of the fungus.—(Ohio E. S. B. 214.)

HOLLYHOCK.

Anthracnose.—It may attack any part of the plant, and is a serious trouble where it occurs.

Leaf Blight.—This is another fungus disease of the hollyhock. These two diseases of the hollyhock should be amenable to spraying with standard fungicides.

Rust.—On the other hand this recently introduced disease of the hollyhock is much less likely to be prevented by spraying. The rust fungus forms dense patches, spots or sori, on the under side of the leaves. These are commonly about one-sixteenth inch or more in diameter, of grayish-brown color and projecting below the leaf surface, while a minute yellow spot early appears on the upper surface of the leaf. Subsequently the diseased leaves drop and by the time the plants are blooming the stem below is bare or disfigured by the remains of the diseased leaves. At the Station this rust has been prevalent and the complaint is general respecting the same trouble. It would seem wise to gather and burn all the affected leaves and likewise the old stems as early as possible. Between anthracnose and rust these popular old flowers are having, at present, a difficult time of it.—(Ohio E. S. B. 214.)

LILY.

Bermuda Lily Disease.—The lily disease is characterized by the spotting and distortion of the leaves and usually of the flowers, spotting of the scales of the bulbs, and generally the stunting of the plants. In severe cases the first leaves as they appear above ground are more or less distorted, and are marked with small, yellowish white, often longitudinal, and more or less shrunken spots or streaks. These increase slightly in size, continue to grow paler, and finally collapse, dry out, and turn light brown. Each succeeding whorl of leaves becomes similarly affected, and finally the flowers show the shrunken spots and the distortions. Sometimes badly affected plants are apparently strong, vigorous growers, but usually they produce only one or two small, distorted flowers.

It often happens that the leaves of a diseased plant are not all affected in the same degree. Several of the lower, middle, or top whorls may be badly diseased, while the others may be comparatively healthy; occasionally the leaves on one side of the stem are much more spotted and distorted than those on the other; or, as is often the case, one side of a leaf will be diseased and the other remain comparatively healthy. Again, the tissues of the stem at the point of attachment of diseased leaves often collapse and turn brown in much the same way as do the tissues of the leaf.—(B. Veg. Path. B. 14.)

When the flowers become spotted, the plants are unsalable, no matter whether the leaves are badly diseased or not, and are therefore a complete loss to the grower. When the flowers and a few of the upper whorls of leaves escape, the plants are usually disposed of for decorative purposes where only the flowers are required. The popular demand, however, is for perfect flowers and perfect leaves, as even a slight disfigurement will cut down the market value of the plant.

Many theories have been advanced as to the cause of the lily disease and in our investigations these have all been studied as far as possible. The writer was, however, unable to obtain bulbs from which flower stems had been cut or which were known to be immature, hence our conclusions relative to these points are only general, having been based on the second growth of bulbs which were developed by forced plants.

Some growers attribute the trouble to exhaustion of food in the soil in which the bulbs are grown. That this is not the case, however, is at once apparent from the fact that it often appears on new land never before planted to lilies and on lands highly fertilized, and from the further fact that healthy plants are frequently grown on old soils which have been cropped to lilies for several years. Another argument against this theory is the sporadic distribution of the diseased plants in a field.

When the secondary bulbs from susceptible plants start to grow, the young growth is usually infected. The explanation for this is that the plants are not only favorable to the insects, but the latter are present in the bulb between the scales ready to attack the new growth as it appears. The writer has found that the insects pass the winter in this way in bulbs planted out of doors.

Preventive Measures.—From what has been said, it is evident that preventive measures against the lily disease must begin with careful attention to the culture of the bulb in the field and with rigid selection of bulbs for use or sale. Every plant which shows the disease should be dug up and destroyed. Only bulbs of strong, healthy plants should be used for propagating purposes. Scales which are spotted should not be used. A second selection should be made when the plants from the scales are transferred to the field, and all those showing spotted leaves or mite-infested roots or bulbs should be destroyed. A third selection should be made in marketing, all badly spotted bulbs and those having decayed bases being destroyed If this rigid selection were practiced by the growers in Bermuda, the quality of the bulbs received in this country would be far superior to what it is at present and the difficulties encountered in forcing would be greatly lessened.

As yet no treatment has been found which will effectually free infested bulbs without injuring them. In our experiments bulbs were soaked in sulphur solution for two to five hours, and while all the mites reached were killed, those protected by the tissues of the bulb escaped. When bulbs were soaked two hours in corrosive sublimate (1/1000 to 1/2000) the mites were not all reached and the bulbs were injured. Soaking two hours in formalin (1/1000 to 1/2000) was not effective and the bulbs were injured. Fumigating with hydrocyanic acid gas (one-tenth gram of 50 per cent KCN per cubic foot of space) for three hours was not effective, although all the mites reached by the gas were killed. It is probable that this gas can be used much stronger than it has yet been tried and may give better results. It is extremely important that the mites and aphides be kept off the plants from the start, for if they once get a foothold it is almost impossible to get rid of them without injuring the plants. The pots may be plunged in coarse coal ashes and the tops mulched with tobacco stems to keep down these pests. When smoking can not be resorted to, a liberal supply of tobacco stems or dust should be used.

The bulbs to be forced should be planted in well-drained, well-aerated soil, containing not more than one-fourth well-rotted organic manure. The roots, as well as the bulbs, require a large amount of oxygen and this they can not obtain if the soil is too wet. Great care should be exercised in watering to keep the water off the young foliage, for, as above stated, the latter is often injured by the water being injected into the intercellular spaces or remaining on the leaves for some time. The houses should be kept well ventilated in order to insure strong plants.

In feeding, solutions of organic fertilizers, like cow, horse, or sheep manure, should be avoided if possible, as they have a tendency to clog the soil. Chemical fertilizers in weak solution will probably give superior results, although this question must be determined by more extensive experiment.

Summary.—(1) The lily disease is characterized by the spotting and distortion of the leaves and flowers and usually the stunting of the plant.

(2) The disease is quite serious on *Lilium longiflorum* and *L. harrisii* and also attacks *L. auratum* and *L. candidum*. It is very prevalent in Bermuda; and in the United States where the bulbs are forced, it destroys from 20 to 60 per cent of the crop. It also doubtless occurs in Japan, France, and the Netherlands.

(3) There are many theories as to the cause of the lily disease, the principal ones being worn-out soil, premature removal of flowers and flower stems, premature harvesting of the bulbs, carelessness in the selection of stock for propagating purposes, bad treatment during forcing, and the work of insects.—(B. Veg. Path. 19.)

PELARGONIUM.

Dropsy.—Some varieties of cultivated pelargonium, possibly called begonia, suffer seriously from dropsy. One bright scarlet flowered variety in particular has been cultivated at the Station. It often suffers from dead spots in the leaves. Before these spots in the leaves die, examination will show that there are wet looking places upon the under side of the leaf which appear translucent when held between the observer and the light. These are nothing more than leafcells which have become so gorged with water as to be ruptured. The break down extends to adjoining parts and then tends to produce the spots before described. This is purely a physiological trouble due to excess of water. The remedy is clear. Withhold water until absolutely necessary.

PEONY.

Stem-Rot—Wilt.—The symptoms are a gradual dying of the leaves. Examination shows stems to be rotted near the ground or often very much higher. A strong, insoluble fungicide might be successfully sprayed upon the stems without covering the leaves.

PHLOX.

Leaf-Spot.—Cultivated phlox is frequently attacked by a leaf-spot fungus *(Septoria divaricatae)*. This mars the appearance of the leaves but is not often serious.

Powdery Mildew.—There is a powdery mildew fungus also *(Erysiphe Cichoracearum)*, sometimes found upon cultivated phlox. It develops as a whitish covering over the leaves and other parts. Both should yield to spraying properly done.

PRIMULA.

Rot.—A rot of Chinese primula due to Botrytis and similar to that on peony has been reported and may be expected with us.

PRIVET.

Anthracnose.—Privet in hedges is frequently attacked by anthracnose *(Gloeosporium cingulatum)*. This shows itself by lesions in the younger stems and results in dying of the portions of the attacked branches beyond the lesions. This weakens the hedge and sometimes results in secondary consequences. While spraying has not been fully worked out for this disease, it should prove an effective remedy at the proper time.—(Ohio E. S. B. 214.)

PLANT DISEASES AND THEIR CONTROL.

Rose Mildew.—Powdery mildew is one of the most common and injurious diseases of roses, wherever they are grown. In regions where the climate is most suitable for outdoor rose culture, mildew is also prevalent; but here it is rarely troublesome except in the greenhouse, where it often causes serious injury. A few varieties, the Crimson Rambler and some related forms especially, are badly injured outdoors, but much less so when grown away from walls so that they have free air exposure.

The mildew is usually first noticed as grayish or whitish spots on the young leaves or shoots, these being more or less distorted by the disease. Later as the spots enlarge they have a white, powdery appearance, or on the stems, or thorns more than elsewhere, may have a quite felt-like coating. After a few weeks as the affected parts mature, the mildew appearance is lost and the injured portions show a dark color.

The young leaves, stems and buds are dwarfed, curled or variously deformed by the disease. The foliage is reduced by the deformation and killing of parts of the leaf surface, and by the dropping of the injured leaves, and growth and flower production is seriously interfered with. The young buds themselves are often attacked by the mildew, the flower clusters of the Ramblers sometimes being completely covered by it and entirely worthless.

Cause of Mildew.—If one of the very young mildew spots which can just be distinguished is examined with a microscope which magnifies 10 or 20 diameters, one can easily see that the spot consists of a mold-like growth. This fungus is composed of slender, white threads with numerous branches, running out from the center of the spot and forming a net-work over the surface of the rose leaf. At various points these threads produce a different kind of branches, which are erect and bear on their ends chains of minute egg-shaped bodies (spores) which are easily detached and in older spots lie in masses on the surface and give it a powdery appearance.—(Md. E. S. B. 156.)

For greenhouse roses, keep the steam pipes painted with a paste made of equal parts lime and sulfur mixed up with water. The mildew is a surface-feeding fungus and is killed by the fumes of the sulfur. Out-door roses that become infested with the mildew may be dusted with sulfur or sprayed with a solution of potassium sulfide, 1 oz. to 3 gallons water. Spray or dust with the sulfur two or three times at intervals of a week or ten days.—(N. Y. [Cornell] E. S. B. 252.)

The apparatus used for this work is called the Campbell vaporizer. In this the sulfur boils over an alcohol lamp but does not burn. This is very effective and safe if the directions are closely followed. The principal feature of this device is the pot in which the boiling takes place. There being only a small opening in the top of this vessel it is almost impossible for the sulfur to get on fire. It must be watched, however, for it will sometimes, if quite full, boil over. The vapors given off in this apparatus are entirely different to those in which the sulfur is burned. Soon after the lamp is lighted a rather heavy, yellow vapor rises from the mouth of the pot. This seems to be composed of very fine particles of sulfur. After a few moments this vapor begins to settle down all over everything in the house. Thus all the foliage is covered with a fine layer of sulfur. The effect on the mildew does not seem to be immediate, but after a few days the grayish looking fungus disappears and nothing but the black scars are left.

The common method of painting the heating pipes with a mixture of sulfur and a small amount of lime has a similar effect on the mildew, but a much less dense vapor is seen.

Maynard of Massachusetts reported in 1889 (Hatch Exp. Sta. Bulletin 4) the successful use of volatilized sulfur for the control of rose mildew, black spot and even red spider. He used a handstove on which the sulfur was kept heated to near the boiling point in a thin iron kettle for 3 or 4 hours, 2 to 3 times a week, or enough to give a visible vapor in the house, taking every precaution to prevent burning the sulfur. A somewhat similar method is used by some

Maryland rose growers. There is much danger of the sulfur taking fire in the open kettle and ruining the whole house.

Mildew, if allowed to get a hold, soon spreads over the entire house, unless conditions are against it. One of the conditions favorable to the spread of mildew is dry, cool air, such as would come into a greenhouse from ventilation, broken glass or open doors. Under such conditions the plants are to a certain extent wilted. The same air conditions favor the spread of the spores. A close and moist condition of the atmosphere is not favorable to the spread of mildew but may make the plants very soft and succulent and the youngest and most succulent portions of the plant are most readily affected by the disease.

The low-down side method of ventilation, while it retards the appearance of mildew, would not be practicable in a range of houses.

The mildew should be controlled when the attack is comparatively slight. If mildew shows, no time should be lost in vaporizing sulfur to kill off the spores. As the fungus develops from the spore and matures a new crop of spores in six or eight days it only takes a short time to infect the entire house. During the winter when firing is going on and the pipes are hot, painting them with sulfur will usually keep down mildew. At other times a sulfur vaporizing appliance will be found very useful. The appliances for burning sulfur are useless to control the trouble and the chance for injury is very great. Outside rose mildew can be controlled by spraying with concentrated lime-sulfur solution, 1 to 50 of water, or any good fungicide, applied frequently.

A very heavy vapor from boiled sulphur does not injure the foliage but did injure outer petals of half blown roses.

An overdose of burning sulphur kills the leaves badly but does not seem to injure the petals of half open buds.—(Md. E. S. B. 156.)

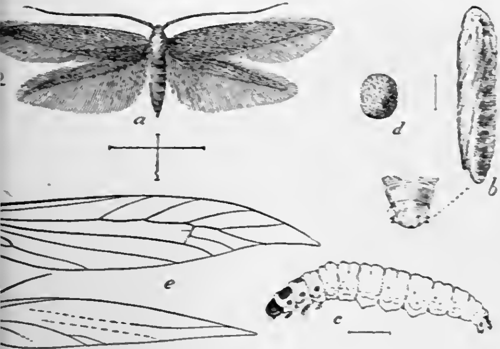
ROSE.

Black Leaf Spot.—This is one of the commonest diseases of the rose. It causes the leaves to fall prematurely. Spray with Bordeaux, 5-5-50, beginning as soon as the first spots appear on the leaves. Two or three applications at intervals of ten days will very largely control the disease. Ammoniacal copper carbonate may be used on roses grown under glass. Apply once a week until disease is under control.

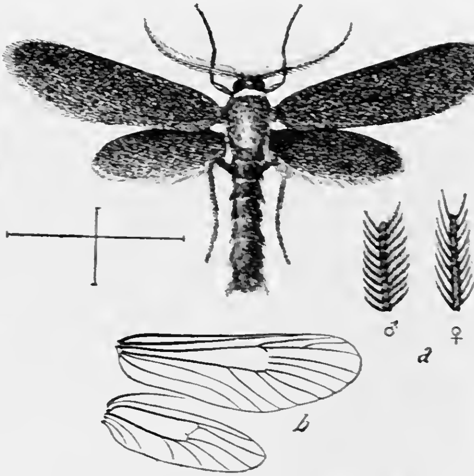
Anthracnose.—An anthracnose fungus *(Gloeosporium rosae)* attacks the rose, causing defoliation of the canes; indeed the whole plant is attacked. This behaves very similarly to the anthracnose fungus of the raspberry. Young plants are found most susceptible to the disease. The methods of handling are practically the same as for the anthracnose of the raspberry.

Crown Gall.—Crown gall trouble essentially the same in character as that of raspberry, occurs on roses but requires no separate description here.

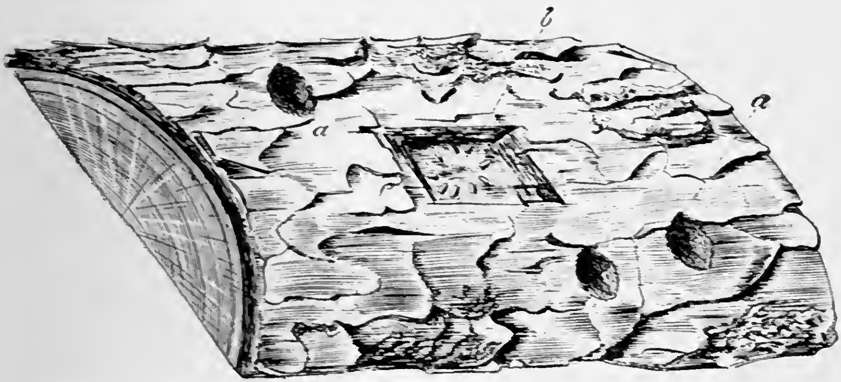
Leaf Blotch (Actinonema Rosae) often causes dark spotting of the leaves. The frost-like, branching growth over the leaf-surface is often very pretty in design though injurious in effect. If the rose-



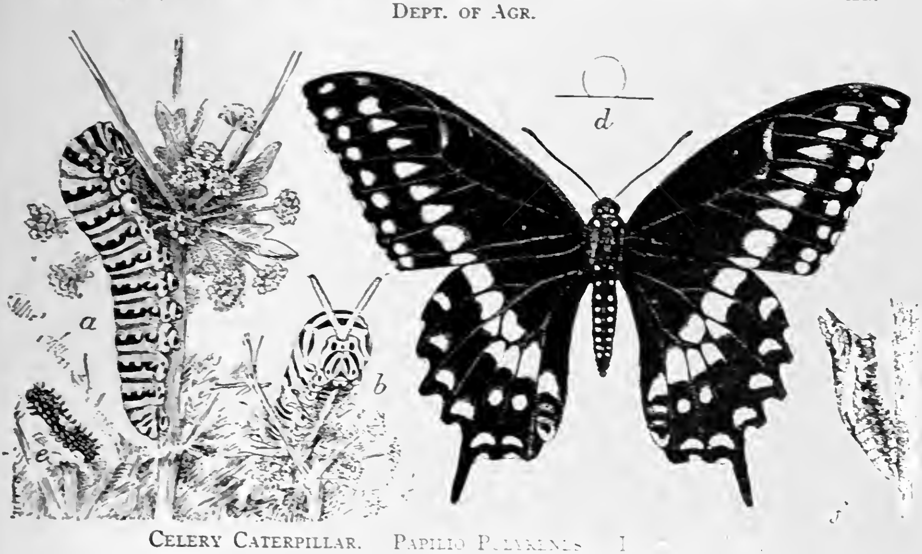
Cigar Case-Bearer in Various Stages.
Dept. of Agr.
(See page 42.)



Grape Leaf Skeletonizer: Male Moth.
Dept. of Agr.



The Pine Sawyer. *A.* Egg Pit. *B.* Eggs in Position in Which They Were Placed by Female, the Outer Bark Being Removed. About One Half Natural Size.
Dept. of Agr.



Celery Caterpillar. Papilio Polyxenes [illegible]

house is too moist, or if other conditions be slightly unfavorable, the fungus seems to flourish all the better. It may be checked by the use of Bordeaux mixture or by dilute copper sulfate solution, as recommended for cucumbers in the greenhouse (One pound to fifty gallons).—(Ohio E. S. B. 214.)

Nematodes.—Among the most serious of the rose diseases is that caused by the eelworms or nematodes which attack the roots. As with cucumbers, these parasitic worms induce the growth of small bead-like galls upon the roots of the rose. The leaves dry up from the margins, the plants generally turning yellow and breaking down as the outcome of this interference with the proper work of the roots. No successful remedy has been found for plants once attacked. The method of prevention consists, as in the case of cucumbers already cited, in the proper steaming and treatment of the soil designed for use in the rose benches.

Rust (Phragmidium subcorticium).—This is occasionally met and proves very disfiguring. As yet we can advise nothing more than the choice of rust resistant sorts.—(Ohio E. S. B. 214.)

SNAPDRAGON.

Anthracnose.—It attacks the plants at any stage of their growth, both in the greenhouse and in the field. In the greenhouse it is more destructive in the fall and spring than during the winter. In the field its ravages are most conspicuous in August and September. On the stems it produces numerous elliptical sunken spots from three to ten millimeters in length; and on the leaves circular dead spots having a diameter of from three to five millimeters. These spots are caused by an undescribed species of *Colletotrichum* for which we here propose the name *Colletotrichum antirrhini.* Cuttings should be taken from healthy plants only. Anthracnose is often transmitted from one generation of plants to the next by means of infected cuttings.

VIOLET.

Spot Disease.—This attacks the plants at any stage of their growth from the small unrooted cutting in the cutting bed to the mature plant in full flower. Plants that are making a vigorous, rapid, but soft or succulent growth are most subject to the disease. The disease may occur on any portion of the plant above ground, but causes the greatest amount of loss when present upon the foliage. Its first appearance upon the leaves is characterized by small, definite, usually circular, greenish or yellowish white spots, resembling very much the bite or sting of an insect. They vary in size from dots scarcely perceptible to the unaided eye to spots a thirty-second of an inch or more in diameter. The light-colored central portion or point of infection is surrounded by a narrow ring of discolored tissue, usually black or very dark brown at first, but changing to a lighter shade as the spots grow older. As the spot develops the central portion remains unchanged in appearance, while the tissues immediately surrounding it, either to one side or more frequently in a circle, become diseased by the ramifying growth of the mycelium of the fungus through this portion of the leaf. This usually takes place within a few hours after infection. The freshly diseased portion of the leaf at first presents a waterlogged appearance, frequently being semi-transparent, and is lighter in color than the adjacent healthy tissue. The diseased portion around the central point of infection in a few days fades or bleaches to a yellowish or grayish white, sometimes to a pure white, the time depending somewhat upon the conditions of the weather. The development of the disease may stop at this point and the plants apparently entirely recover from its effects; in which event the diseased portions of the leaves after a few days separate from the healthy tissue and fall out, leaving the leaves full of holes. More frequently, however, the disease continues to develop in the parts of the leaf adjoining or surrounding those already diseased. These freshly diseased areas in turn pass through the same changes as the parts previously attacked. Unless checked by some means the disease continues to spread in this way until the entire leaf is destroyed. It is seldom, however, that a single spot upon a leaf develops to this extent. More frequently the leaf is attacked at a number of different points, and as the disease progresses the spots become larger and one or more of them coalesce, forming large irregular areas or blotches upon the leaf. A well-developed spot of this disease therefore shows a light-colored central portion, the point of infection, partly or wholly surrounded by alternate rings of dark and light colored tissue, the lighter colored portions, as a rule, being very much broader and more conspicuous than the darker. The majority of these spots are usually free from fungus spores except under conditions peculiarly favorable to their development. Spores are produced, however, in great abundance upon most of them, especially upon the central or older portions of the spots, after the leaves have been placed in a saturated atmosphere for from twenty-four to forty-eight hours. It is frequently the case that spores are produced in sufficient numbers to be discernible by the unaided eye, but usually the aid of a hand lens or a microscope is necessary to determine their presence. The spores are borne in chains on dark brownish hyphæ that rise from the diseased surface. The spores break from their attachment and separate from each other easily, and being very small and light they are carried around by currents of air and finally settle upon other leaves.

Perhaps no subject relating to floriculture has received more attention in the floricultural and horticultural journals during the past eight or ten years than the disease in question. The most varied opinions have been expressed in regard to it, and the explanations advanced as to its cause and the possible course of treatment are numerous. Some of the more important of these hypotheses are given here.—(Div. Veg. Path. and Path. B. 23.)

So far as we are aware there is at present no effective remedy for this disease when it has gained a foothold. The principal fungicides in common use for the prevention and check of plant diseases have frequently been tried for this trouble, but with varying results. The experiments of the Division in spraying violets with some of the more important of these, among them Bordeaux mixture and ammoniacal solution of copper carbonate, seem to show that they possess little or no value in preventing the disease, while on the other hand they render the foliage worthless for bunching with the flowers, and thus occasion considerable loss and inconvenience. From the writer's experience and that of many others it would seem that the solution of this problem of controlling the disease lies in preventing it by giving careful attention to the production of vigorous, healthy, plant growth rather than in attempting to check the trouble after it has once gained a foothold.

The successful growing of violets free from disease and the production of flowers of the best quality are governed by a number of factors which must be kept in mind. The principal rules which should govern the grower are the following:

(1) Study carefully the behavior of the plants under the varying conditions surrounding them. Endeavor by modifying these conditions, when necessary, to secure plants of ideal development. Set the standard of excellence high and be satisfied with nothing short of its attainment.

(2) Grow the plants during the entire season where they can be given the conditions necessary for making a vigorous, healthy growth, and where they can be protected at all times from conditions likely to induce disease.

(3) Keep the houses or frames clean, sweet, and in perfect condition for growing healthy plants, by repairing and painting them when necessary, and by removing and destroying all rubbish likely to harbor vermin or disease.

(4) Propagate only from healthy, vigorous stock of known parentage at the season most favorable to the plants.

(5) Select each spring none but perfectly healthy, vigorous plants from the rooted cuttings for planting into the houses or frames. Old plants are sometimes carried over, and occasionally yield a large crop of flowers. They are not as reliable as the young plants, however, and are much more liable to all kinds of disease. The best growers rarely use them if it is possible to secure strong, healthy young plants for spring or early summer planting.—(Div. Veg. Path. and Phys. B. 23.)

(6) Keep the plants clean of yellow, dead, or dying leaves, being careful to destroy them after removing them from the plants.

(7) Keep the plants free from insects and other animal pests.

(8) Give careful attention to ventilating, heating, and shading the houses or frames and to watering, cleaning, and cultivating the plants.

(9) Renew the soil in the beds each season before setting in the young plants by removing from eight to twelve inches of the surface soil and replacing it with that freshly prepared.

(10) Set the young plants early in the spring in the beds where they are to remain during the season, so that they may get well established before the hot, dry weather of summer makes its appearance.

Careful attention given to the above directions for a number of years will, it is believed, result in the production of a strain of plants that are not only practically disease resistant, but are also ideal as regards regularity and symmetry of growth, length, and strength of flower stems, and yield, size, substance, and quality of flowers produced.—(Div. Veg. Path. and Phys. B. 23.)

Leaf Blight (*Phyllosticta Violae* and *Cercospora Violae*) are sometimes prevalent, and with downy mildew of violet should yield to spraying with fungicides.

Nematodes.—These are, on the other hand, not amenable to spray treatment. The parasite in the case is the same as named under cucumber nematodes, likewise its effects. Soil treatment will also be effective in prevention here.

Root-rot (*Thielavia basicola*).—This has not been reported as troublesome by greenhousemen in Ohio, but it is scarcely possible it can be entirely lacking when the disease occurs upon tobacco and catalpa in fields. The blackening and rotting of the roots, due to the fungus, will impair the development of the plants and the flower growth seriously. It does not seem possible that anything short of sterilizing the soil and starting new plants will check the root-rot where once established.

VIRGINIA CREEPER.

Leaf-Spot.—The leaves of virginia creeper are frequently curiously spotted by a leaf-spot fungus (*Phyllosticta labruscae*) which gives dying spots with colored border. This leaf-spot is also very common upon the Japan creeper and is identical, according to recent reports, with the leaf-spot of the grape; indeed we have a large number of the well known diseases of the grape attacking the Virginia creeper. These include anthracnose, which may be distinct, the black-rot fungus, of which this Phyllosticta may be a stage and possibly others. This would be especially true in the vicinity of cultivated grape vines.—(Ohio E. S. B. 214.)

DISEASES OF FOREST TREES.

ASH.

Trunk Rots.—The ash as a forest and shade tree is a vigorous grower, but it is often marked by the attacks of timber decays where these enter through wounds or by means of the bases of dead branches. We have urgent need for more knowledge of these wound parasites.

Leaf-Spots and Rust.—The foliage of the ash is attacked by rust (*Puccinia fraxinata*) but in the present state of our knowledge we are unable to apply effective remedies. This rust, as in the case of other rusts, shows by the presence of its reddish or brown colored spore masses. Of leaf-spot fungi there are a number which call for careful study.

BEECH.

Anthracnose.—The anthracnose fungus (*Gloesporium Fagi*) of beech attacks the leaves, but is not so serious as many of the other anthracnoses.

Leaf Diseases.—While the beech is not largely planted, it is nevertheless a useful shade tree. The leaves are often attacked by two or three mildews (*Microsphaera erinophila penicillata* and *Phyllactinia suffulta*), which, however, rarely gives serious injury to foliage. In Europe the beech is attacked by a rust fungus (*Melampsora Fagi*); the leaves are also attacked by a leaf-spot species of *Phyllosticta*.

BIRCH.

Anthracnose.—The anthracnose fungus of birch (*Gloeosporium Betularium*) attacks the leaves of our American birches while other anthracnoses are known on the European species. Our knowledge of the injury is very limited.

Mildews.—The downy mildews of beech and alder in part occur upon the birches.

Wound Fungi.—Characteristic flesh fungi invade pruning or other wounds in the birch and are to be guarded against as with other woody growths.

ELM.

Bleeding.—Bleeding of pruned elm trees is often annoying as well as dangerous. Asphaltum covering over cut surface reduces or cures the bleeding. This is successful when searing by torch precedes application of dressing.

Black-Spot.—The leaves of ornamental elms are attacked by black spots (*Dothidella ulmi* and *Gnomonia Ulmea*) which sometimes injure the leaves, and by this means checks the tree.

Other leaf diseases also occur upon the elm. One of these is a leaf-spot (*Phyllosticta ulmicola*) which matures its spores in the fallen leaves. Gathering and burning these infested leaves will prove a check on this fungus.

Powdery Mildews (*Microsphaera Alni* and *Uncinula macrospora,* more often the latter) likewise attack elm leaves. If troublesome these should be reached by applications of Bordeaux mixture, making the first application when the leaves are half grown.

Timber-rots are also known on the elm; to be guarded against in wound infection of shade trees.

Twig Disease.—In portions of Ohio and in Kentucky a dying of elms which are prized as shade trees has been reported. This disease shows first as a loss of leaves at the ends of twigs, often at the tops of trees. It is believed that changing soil conditions have much to do with this disease. To the writer it would seem that the water factor with this, as with many other shade trees, may prove a determining cause.—(Ohio E. S. B. 214.)

HEMLOCK.

Hemlock grows freely with us and is apparently quite free from foliage troubles.

Heart-rot (*Trametes pini*) and Sap Rot (*Fomes pinicola*) are reported from districts where special attention is given to the conditions.

HICKORY.

Leaf-Spot.—A hickory leaf-spot (*Marsonia juglandis*) is quite general and leads to dying of the leaves prematurely.—(Ohio E. S. B. 214.)

MAPLE.

Anthracnose (*Gloeosporium apocryptum*).—This disease attacks young Norway maples (see N. Y. Sta. Report '95) and has been also identified on the young shoots of sugar maples in Ohio. The new leaves were reported destroyed by the fungus which is much more common in Ohio on sycamore trees. Applications of Bordeaux mixture should check this disease.

Rhytisma and Leaf-spot.—The leaves of cultivated maples are often disfigured by dark colored incrustations following the line of the veins. These incrustations are almost black and are caused by a fungus (*Rhytisma acerinum*). The trouble is usually not serious, but if prevalent it would seem advisable to gather and burn all leaves attacked by it. The leaf-spot fungus (*Phyllosticta acericola*) often causes small spots, or dead areas, in the leaves. This may sometimes prove so serious as to call for applications of fungicides.

Mildew.—Maple leaves are overrun by the powdery mildew fungus (*Uncinula*) at times, but this is not difficult to check even if spraying becomes necessary.

Tip-Burn—Sun-Scald.—Tip-burn conditions upon the maple in 1908 and 1909 were similar to those described for horse chestnut and evidently due to secondary consequences of insect punctures.

Sun-Scald or Winter Injury.—These are frequent upon maples after the manner of those described for apples. They are due to a killing of unripened tissues by premature freezing and are only preventable by avoidance.

OAK.

Anthracnose.—The oak leaves are attacked by the same anthracnose fungus as attacks the leaves in young shoots of sycamore and maple, but this is not so prevalent upon oaks in Ohio as upon the sycamore.—(Ohio E. S. B. 214.)

PINE.

Damping-Off.—A damping-off fungus (*Fusarium*) has recently been very troublesome with seedlings of white pine in the east. This has been investigated and remedies have been tried successfully. These are either dilute sulfuric acid or powdered copper sulfate and lime; the former being sprayed on the seedlings about the base and the latter applied as dust. It is likely that with efforts to grow white pine for timber purposes in this state, troubles of this type will not be restricted to this parasite.

Leaf Blight and Leaf-Spot.—Leaf troubles have been met in most areas where white pine grows naturally or is being cultivated very largely. One of these so-called leaf blights is referred to a fungus (*Septoria parasitica*). It has been found in adjoining states if not in Ohio. Another leaf-spot fungus (*Phoma strobi*) is quite prevalent upon white pine in Europe. It is believed that this parasite or a closely related one (*Phoma strobilinum*) occurs within our borders. Remedies have yet to be worked out for these troubles.

Root-Rots.—These are to be expected in addition to the damping-off fungus before mentioned, especially among seedling pines under culture.

Rust.—In Europe the blister rust fungus (*Cronartium ribicolum Peridermium strobi*) has been long known as a serious drawback to the culture of the white pine. Curiously enough this rust has until recently not been known in the United States. Not long since warning was sent out by the Department of Agriculture that this rust had appeared in America and should be sought for upon its alternate hosts, the white pine (*Aecidia*) and the currant and gooseberry. (*Uredo- and Teleutospores.*) Upon the pine the aecidial stage develops numerous orange cluster cups infecting the stem toward the base. This causes high mortality among the young pines. Upon the currant and gooseberry the uredospores show yellow color which darkens as the teleutospores form. These are to be sought in August or early September, and by reason of the importance of this rust merit early attention by students of these diseases.

POPLAR.

Anthracnose.—Species of poplar or cottonwood are at times attacked by anthracnose (*Marsonia populi*). It produces similar effects to those of anthracnose upon sycamore.

Rust.—The leaves of poplars are frequently attacked by the rust (*Melampsora populina*) which disfigures the leaves by the spots caused through its development. The thrifty growth of poplars usually overcomes these foliage diseases under favorable conditions.

SPRUCE.

Leaf-Spot.—Norway spruce in Ohio has suffered seriously in 1908-9 from attacks by a leaf-spot fungus (*Phoma*). This fungus causes the discoloration of the leaves (needles) also their dropping. The fruit bodies of the fungus occur upon the scales of the branches as well as upon the leaves and are evidently capable of surviving from year to year. This leaf-spot or leaf blight has been reported from several counties upon hedge plantings, upon large shade trees and upon sizes grown for Christmas trees. Drouth conditions in 1907 were a large factor in this matter causing the death of many spruce trees in 1907 and 1908. It is believed that winter and early summer sprayings will have some effect in checking the leaf trouble. This experience shows the need for mulches about Norway spruce, especially in the southern portion of Ohio. Seedling diseases are liable to prove troublesome thus checking efforts to grow seedlings of spruce.—(Ohio E. S. B. 214.)

CHESTNUT BARK DISEASE.

The disease is caused by the fungus *Diaporthe parasitica.* The spores of this fungus, brought by some means from a previously diseased tree, enter the bark through wounds; possibly also in other ways. The leaves and green twigs are not directly affected. From the point of infection the fungus grows in all directions through the inner bark until the growth meets on the opposite side of the trunk or limb, which in this way is girdled. The wood is but little affected. Limbs with smooth bark attached by the fungus soon show dead, discolored, sunken patches of bark covered more or less thickly with the yellow, orange, or reddish-brown pustules of the fruiting fungus. In damp weather or in damp situations the spores are extruded in the form of long irregular "horns," or strings, at first greenish to bright yellow in color, becoming darker with age. In this illustration the typical appearance of the pustules in damp weather and the projection of the spores of the fungus in the form of horns, or threads, are shown. These threads may be especially conspicuous near the edges of diseased areas. If the spot is on the trunk or a large limb with very thick bark there is no obvious change in the appearance of the bark itself, but the pustules of the fungus show in the cracks of the bark and, on account of the destruction of the layers beneath, the bark often sounds hollow when tapped. A patch usually grows fast enough to girdle the branch or trunk that it is on during the first summer.

The damage may not be immediately apparent, since the water supply from the roots continues to pass up through the comparatively uninjured wood to the leaves, but when in the following spring the new leaves are put out they are usually stunted and soon wither. The imperfectly developed leaves often persist on the dead branches throughout the summer.

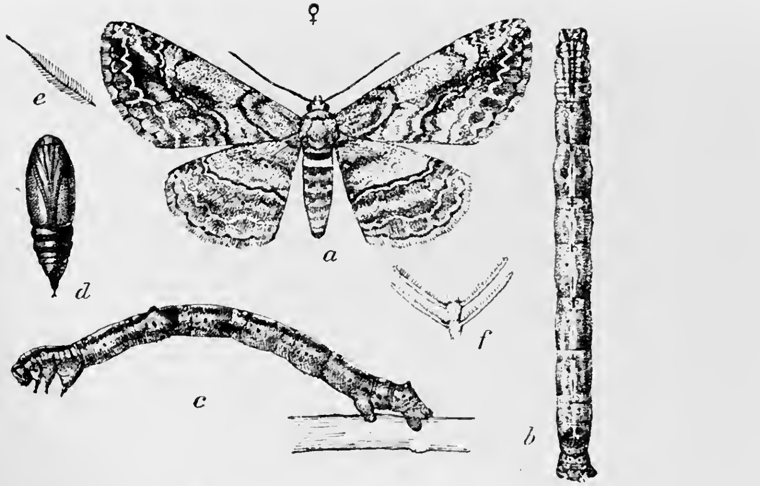
The great damage which the disease has done thus becomes most apparent in the last week of May or the first week in June, giving rise to the false but common idea that the fungus does its work at this time of the year, when in reality the harm is done during the previous summer. If the first attack is on the trunk, of course the entire tree dies. If, on the other hand, the small branches are first involved, the tree may live for several years.

States have suffered from a disease during the past twenty years, since, as already stated, that is a totally different thing from the bark disease.

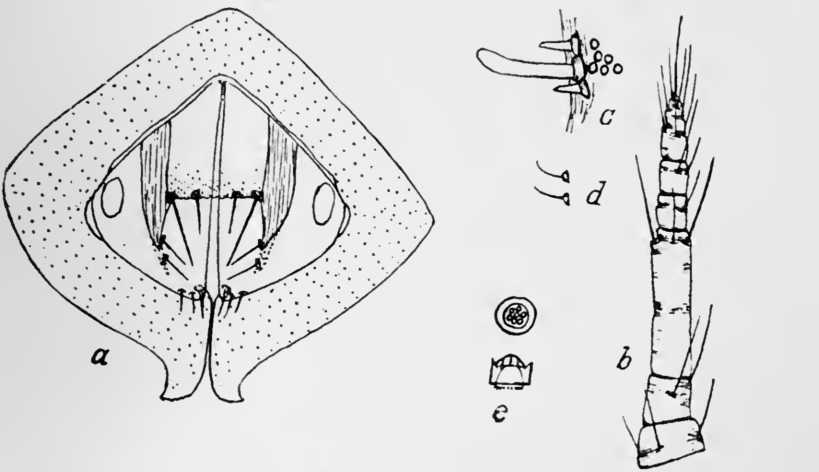
Where the bark disease is already firmly established and has attacked 50 per cent or more of the chestnut trees, as in the vicinity of the city of New York, it is probably too late to try to do anything, but where the disease is just appearing there is no reason to doubt that strict quarantine methods will apply as well to this as to any other disease, whether of plants or animals. The question to settle is simply which is more costly—to use the methods recommended or to lose the tree. The people concerned must decide.—(F. B. 141.)

The Extent of the Bark Disease.—The bark disease of the chestnut has spread rapidly from Long Island, where it was first observed, and is now reported from Connecticut, Massachusetts, Vermont, New York as far north as Poughkeepsie, New Jersey, Pennsylvania, and possibly Delaware. It is no exaggeration to say that it is at present the most threatening forest-tree disease in America. Unless something now unforeseen occurs to check its spread, the complete destruction of the chestnut orchards and forests of the country, or at least of the Atlantic States, is only a question of a few years' time.

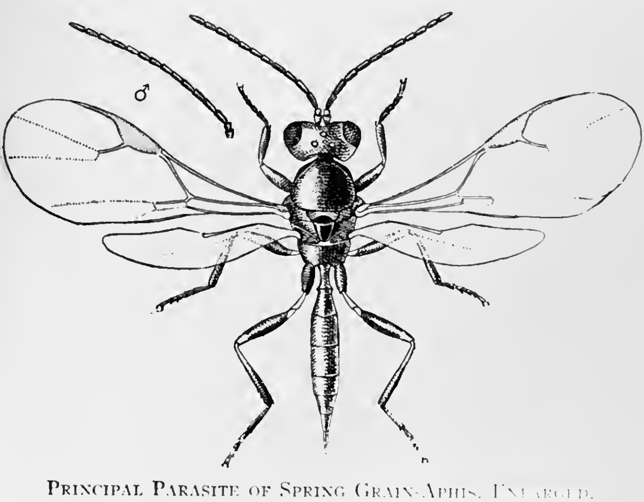
Observations made by the writer during the past year indicate that all varieties and species of the genus Castanea are subject to the disease except the Japanese varieties (*Castanea crenata*). All of the latter that have been observed in the field or tested by inoculations have been found immune. This fact can hardly fail to be of funda-



CRANBERRY SPANWORM (CLEORA PAMPINARIA). DEPT. OF AGR. (See page 99.)



TERRAPIN SCALE (EULECANIUM NIGROPAS). DEPT. OF AGR. (See page 53.)



PRINCIPAL PARASITE OF SPRING GRAIN-APHIS, ENLARGED.
DEPT. OF AGR.

mental importance to the future of chestnut nut culture. Although the nuts are distinctly inferior in flavor to the European varieties, such as Paragon, the Japanese chestnut is already grown on a large scale as a nut-producing tree. There are, however, many trade varieties of dubious origin. Some of these may prove later to be subject to the disease. Immunity tests of all known varieties of chestnuts have been undertaken.

Attempts will also be made to hybridize the Japanese with American and European varieties, with the hope of combining the immunity of the former with the desirable qualities of the latter.

However excellent as a nut and ornamental tree, the value of the Japanese chestnut as a forest tree is doubtful. It can be recommended only experimentally at present for forest planting. It certainly will not take the place of the American chestnut. The tree is said to attain a height of 50 or 60 feet in Japan. As seen in this country it is a handsome tree, dwarfish and compact in habit, and rather slow growing. It has hardly had time to show how large it can grow.—(B. P. I. B. 121, Part VI.)

The immunity of the Japanese chestnut, together with the fact that it was first introduced and cultivated on Long Island and in the very locality from which the disease appears to have spread, suggests the interesting hypothesis that the disease was introduced from Japan. So far, however, no facts have been adduced to substantiate this view.

WALNUT.

Blight.—Causes a black spotting on the surface of the young nuts, many of which drop prematurely. Affected nuts which reach full size have the contents blackened and spoiled. The shoots are also affected with the production of black, canker-like areas, most of which heal out as the wood hardens, leaving wounds and cankers of considerable size. Many of the small fruit spurs and twigs are entirely killed, but the disease does not kill large limbs or whole trees. The leaves are also affected in black spots. The disease varies in abundance from year to year, being most prevalent in seasons with much fog and moisture late in the spring.

No practical remedy has been found for this disease, but the problem has been largely solved by the development of immune varieties. Such trees are now available to a limited extent and must soon supplant the present plantings of seedlings or susceptible kinds.

Some control may possibly be obtained by spraying with Bordeaux mixture or sulphur sprays just before the buds open. The expense of spraying walnut trees thoroughly is so great, and so much time is required to thoroughly cover trees of this size, that we have no faith in a satisfactory solution of the walnut blight problem along this line.—(Cal. E. S. B. 218.)

On old groves liberal fertilization with nitrogenous fertilizers, together with the use of green manure crops, will go far towards making up for the losses caused by the disease. Most walnut groves would be benefited by more irrigation than they receive at present, particularly during the winter and in the fall after the crop is harvested.

Trunk Rot.—The trunk or main branches rot, with a production of small, white bracket toadstools on the surface of the affected wood. This fungus does not affect sound trunks, but follows deep wounds, bruises, heavy cutting, sunburn or other injuries. The wood of the English walnut is particularly susceptible to this form of decay. All severe cuts or wounds should be carefully covered with grafting wax to allow healing over without decay. In top-grafting walnut trees this should be given special attention or serious decay may follow.

Sunburn.—Serious damage is sometimes caused from this source, both on the fruit and the tree. In the latter case the trunk is usually affected, dead areas developing in the bark on the sunny side. This originates mostly in winter when the nights are cold and the days bright and sunny. Not usually serious on thrifty trees growing in good soil. Black walnut trunks with rough bark are not affected by sun burn, so that trees grafted high on such trunks are immune.

On the fruit the sun sometimes has a disastrous effect, causing a blackening and burning of the husk on one side during extremely hot weather in summer. The meat is also blackened, and the husk sticks to the shell so that separation is difficult and a black spot is left. Thrifty trees are less affected, particularly when supplied with an abundance of moisture at the root. Individual trees or varieties vary in susceptiblity to this trouble, and this quality should be considered in planting in localities where trouble from sunburn is likely to occur.

Perforation.—The shell fails to develop properly, being only partially formed with numerous openings and thin places. This appears to be simply a lack of development due to climatic conditions and occurs in season with a dry spring and a dry, hot summer. Seems worse on trees attacked by aphis.

Erinose.—Blister-like swellings appear on the leaves, sometimes becoming very abundant. This trouble is caused by an insect, so minute that it is not visible to the eye. Not serious or requiring treatment.

Die-Back.—The limbs die back from the ends, sometimes for only a short distance and sometimes down to the main forks of the tree. All the limbs or only a part of them may be affected. Two general types of die-back may be distinguished, one on the old trees, particularly "hard shells," which die back slowly all over the top, and another in young trees from two to ten years old, which die back suddenly during a single winter in part or all of the limbs, or sometimes the whole tree dies back clear to the ground.

The former type of die-back affecting old trees occurs mostly on light soils where the trees are getting old and the roots find insufficient moisture. Such dying back is also hastened by lack of cultivation, irrigation and plant food, which lack becomes more pronounced as the trees grow older, and the tops and roots more crowded. The only remedy for this trouble is to thin out the trees where they are too closely planted and give the soil better care. Most of these old hard shell orchards, even at best, have now become so unprofitable and undesirable as to make it seem better for the owners to cut down the trees and use the land for some other purpose.

The second form of die-back mentioned, that occurring in young trees which have formerly been thrifty, killing them down to the forks or even to the ground, is a very serious matter at present in some districts. The trouble shows usually to a greater extent in a certain portion of the orchard or in certain orchards worse than in others near by. It developed more extensively in the spring of 1911 than ever before, when a great many trees which had seemed healthy and vigorous the previous fall were found to be almost entirely dead in the spring. Affected trees failed to leaf out at the proper time and more or less of the top proved to be either entirely dead or developd very slowly later in the season. Such trees often threw out new growth or suckers toward the base, which made a very vigorous growth, while the tops were dead or very slow in coming out. The leaves which finally developed from the affected limbs had a yellow, sickly appearance.

This trouble is more or less the same as that described under walnut Yellows, and evidently has been caused by the abnormally dry season of 1910. The disease is practically the same in its nature as that described as the Little Leaf of the peach and shows similar relations. Trees standing over coarse, dry subsoil or those which had for any reason become drier than usual during the fall of 1910 showed the trouble the worst. Young trees under ten years of age showed the trouble worse than older ones. It is a common practice in some of the worst affected districts to grow alfalfa between the walnut rows and in groves or portions of groves which for this reason became drier than the average late in 1910 the trouble has been walnut rows and in groves or portions of groves which for this reason on account of several years' irrigation and handling of alfalfa prevented the moisture reaching the subsoil and thus the same effect was produced. Frost was also responsible to a greater or less extent for the dying back of trees in dry ground.

Trees affected in this way should be pruned back to good live wood, if not too far gone, and it is not to be expected that a new top will soon be produced. By popular attention to irrigation late in the season, especially in dry years, it is not to be expected that the trouble will occur again save in soils most unsuitable for walnuts on account of coarse subsoil near the surface. We may say here that in choosing crops for interplanting walnuts, it is not desirable to let the ground remain in alfalfa too long unless an abundant water supply is available, and one can be sure by actual examination that the soil is sufficiently moist at all times, both for the alfalfa and for the trees. In any event, it is ordinarily best to leave a cultivated strip at least eight feet wide on each side of the tree row, and as the trees grow older it is better to plow out the alfalfa and grow some annual crop which will receive regular cultivation, as well as irrigation.

Yellows.—Spindling, yellow shoots develop which usually die back from the tip. All degrees of the trouble may occur from slightly unnatural yellowing and slenderness of the normal shoots to the production of masses of small, yellow shoots, with continual dying back. This affects the English walnut, and is even more pronounced on the Northern California black walnut in certain seasons and places. It has been abundant even on black walnut trees of large size in some parts of Northern California during the last two or three years, and very prevalent in nursery trees of the Northern California species grown in the southern part of the State. At the same time and in the same nurseries seedlings of the Southern California black walnut have never shown the slightest indication of this trouble. This disease appears to be the same which affects the peach (which see), and also to some extent the pecan, apple, and many other trees. It is probably due to a climatic or soil condition rather than to any parasite. Conditions which result in sour sap and similar troubles in the stone fruits seem to be related to this disease, and it is very likely due to a disturbance of the dormant or resting condition through which these trees normally pass during the winter. Also seems to be connected with lack of rain or irrigation late in the season.

Crown Gall—Black Knot.—Walnut trees are affected in some instances with large knots or cankers on the trunk just below ground or a slight distance above ground. This trouble is not a common one, but seems to occur in some districts more than others. Whether such knots are due to the real crown gall organism (*Bacterium tumefaciens*) has never been determined, but their appearance leads one to suspect that they originate from infection of scars or wounds on the trunk by this parasite. Known only upon the English walnut. As soon as the trouble appears cut out the diseased tissue, disinfect with strong bluestone solution and paint over the wound.

Crop Failure.—It is a very noticeable fact in connection with the California walnut industry that the total product of the groves of the state is not materially increasing, although the acreage has multiplied many times during recent years. This is due to a very general condition of poor production in the large walnut-growing sections of the southern portion of the state. The older groves, although by no means at an age when they should be deteriorating, show very little tendency to increase their yield, and in many cases are gradually going back. The quality and size of the nuts, as well as the quantity, is also a source of complaint. Many of the nuts which mature are empty or poorly filled with shriveled, light weight meat, giving the nut when cracked an unattractive appearance.—(Cal. E. S. B. 218.)

Trouble of this nature is quite commonly attributed to walnut blight, with which disease, however, it has nothing to do. There is probably no one cause or reason for this condition. It is due, generally speaking, to a loss of vitality in the trees, brought about mostly by unavoidable mistakes made in planting when the industry was new and experience in walnut growing very limited. In the first place, all the older groves were planted with the trees too close together. At the common distance of forty feet the branches begin to touch before the trees are ten years old, and by the time they reach full bearing age, the ground is completely shaded and the tops of the trees form a solid mass throughout. This condition is extremely unfavorable to walnut production, and as the groves grow older is the cause of more and more lessening of the crop.

Another factor in walnut deterioration has been the common idea that these trees require very little cultivation, irrigation, or fertilization and the very irregular attention which they have received in this respect. It is true that many walnut trees exist which receive no cultivation whatever and produce very good crops. Such trees, however, usually stand out by themselves with full exposure on all sides, and moreover, while the ground about them is not cultivated, it is at least subject to uniform conditions. The walnut tree seems to particularly resent radical changes in soil treatment. It may do well with no cultivation and will do better, other things being equal, with good cultivation, but it is decidedly injured by irregular treatment in this respect.

Another feature of the situation is the fact that all our older groves are seedling trees, growing thus on their own roots. The English walnut root of the type most commonly grown in Southern California is thrifty and vigorous when soil conditions are very favorable, but has little ability to withstand hardship. Many of the present walnut groves have been planted on soil which for one reason or another is not well adapted to this root, and as a result the trees gradually fail as they grow older.

Again, the inherent nature of the trees in regard to quality and quantity of production is responsible to a considerable extent for the present unsatisfactory condition. Almost every walnut tree over ten years of age in Santa Barbara, Ventura, Los Angeles, and Orange counties is of the type known as the Santa Barbara soft shell seedling. These have all descended from a few trees of the original planting of Joseph Sexton and have in most cases been planted with no discrimination or selection of the nuts. As a result of this the type has degenerated to a marked extent and a large proportion of the present trees are decidedly inferior inheritently to their original parents.

In addition to all this, the climatic conditions of the last two or three years have been such as to have a decidedly unfavorable effect upon walnuts, as described in other portions of this bulletin. The case is, therefore, not altogether hopeless, since it is to be expected that even under present conditions we may have better walnut seasons and crops than those of the past few years. With better and more regular cultural care of the orchards which is now coming into practice, there is still more hope for the future. Growers are beginning to realize that some of the attention which they give their orange and lemon groves might not be wasted upon walnuts.

The faults outlined above may be counteracted to a considerable extent by thinning out the closely planted trees, either by removing a portion of the tops or taking out some of the trees bodily, and by giving the groves cultivation, irrigation, and fertilization along rational lines. The fact is apparent, however, that the present seedling walnut groves have had their day and that they will gradually disappear just as the seedling apple, the seedling orange and all other fruits of the same nature are gradually supplanted by more desirable, definite varieties. The real hope of the walnut industry lies in the future, and is based upon an entirely new start along the lines just mentioned. Upon this basis there is absolutely no doubt but that the walnut will again come into its own and prove one of our most attractive and profitable crops. A complete bulletin upon walnut culture in all of its phases is now under preparation by the senior writer.—(Cal. E. S. B. 218.)

DISEASES OF STORED PRODUCTS.

Rot Disease Losses in Storage.—No sharp line can be drawn between diseases of edible plant products which usually infect these crops previous to harvest, and the rots, molds or decays in such fruits and vegetables during storage. It has seemed best, for this reason, to insert here a brief discussion of these storage troubles which apply to products grown in our region. We can scarcely be called on to present the facts concerning the diseases of citrus fruits in storage or in transit.

All growers of fruits and vegetables in our state are liable, however, to have had losses from rots of fruits and vegetables during storage upon the farm. In the more recent custom of concentrating such storage products in cold storage plants, especially constructed for that purpose, the problem has only been transferred or transplanted: the difficulties have not been entirely overcome.

For the fruits known as perishable, namely, for peaches, plums, cherries and grapes, the custom of brief storage has become well established; the rots or other injuries, such as those that come from crushing, are well known. The storage rots are not different from those commonly found in the orchards—indeed, they are usually the common soft-rot of stone fruits, *Monilia fructigena.* Storage or transit losses from it are but an accentuation of orchard conditions. Also with the stone fruits, as a result of bruising and shipment, we have various of the common molds which develop on the bruised surfaces. The more usual ones are the common bread mold, *Mucor,* the blue mold, *Penicillium,* or the almost equally frequent form of green mold, *Aspergillus.* None of these, however, is likely to penetrate very deeply and be a serious enemy of these fruits. This arises, however, not so much out of the lack of ability to injure by these mold attacks, as from the very brief period of time which these tender skinned stone fruits are held before consumption. As has been pointed out by Powell and Smith, the same common molds, including especially Penicillium, possibly with the aid of others, are sources of serious loss in the handling of citrus fruits—oranges, lemons, etc., during their prolonged periods of transit and storage.

In the case of grapes the losses are almost altogether due to breaking of the skin following which molds and bacteria are liable to appear under favorable conditions.

Storage Rots of Apples and Pears.—With apples the commonest storage rot for our district is doubtless also the commonest orchard rot, namely, black-rot, due to the black-rot fungus, *Sphaeropsis malorum.* All are familiar with orchard conditions liable to prevail at ripening time. This fungus is generally found, especially in orchards of mixed varieties, because some sorts are commonly attacked by it. The same fungus causes cankers upon branches of the susceptible varieties and is usually well distributed over orchards. The punctures of worms or of bees, or wounds caused by mechanical injuries such as occur in wind-falls, and the various drops at picking time, afford easy entrance for the fungus. In consequence we must expect that the fruits which have been in any way punctured or injured, have also been exposed to infection by the black-rot fungus. Such infected fruits are very liable to rot because of the progress of the fungus, if conditions are favorable. The high temperatures of storage sheds and ordinary freight cars during October and early November in our climate, are such as favor its development.

In the light of our present knowledge the best we can do is to transfer fruit as soon as possible to storage where the temperatures are low enough to restrict the fungus. It follows without saying, that good results are obtained only from absolutely sound fruit, and the low temperatures of cold storage houses, 42 degrees or below, may be relied upon to check this rot to a very large extent, provided only sound fruits are placed in storage.

Naturally the discussion which follows under the storage of onions will raise the question here as to the practicability of gaseous disinfection of apples by the use of formaldehyde gas. It would seem possible under favorable weather conditions when fruit can be gathered dry and brought into storage houses in that condition, to disinfect the fruits by the formaldehyde gas method. Of course it follows that the period of disinfection will be brief in order that little or no gas will be absorbed by moist or exposed fruit surfaces, since formaldehyde is objectionable in food stuff. The time of fumigation may not need to be more than about half that used for potatoes or onions, and the strength of the formula may even be modified. The aim would be the destruction of external spores, etc., which certainly are a menace at all times.

The bitter-rot fungus (*Glomerelia rufomaculans*) may also develop in storage apples where these have become attacked by it before harvest. The bitter-rot may be more common upon late summer and fall varieties in transit, than in ordinary winter storage. Certain sweet apples, such as Bentley Sweet, are very susceptible to bitter-rot losses in storage. Cold storage temperatures hold back the development of the fungus, but cannot disinfect the diseased fruits.

Pear rots with us are almost exclusively those which occur in the orchard. The leaf-spot fungus (*Entomosporium maculatum*) also attacks the fruits of pear and may become a source of loss in storage. This applies more particularly to inferior grades of fruit. Pacific coast fruit which is shipped to our district, may further suffer from some of the ordinary molds which find access to the fruit entirely through bruised or other injured areas.

The brief storage of quinces usually does not lead to much further development of the quince rot. The fungus in question is commonly the same as that in the apple rot (*Sphaetropsis malorum*).

Storage Rots of Potatoes, Onions, Etc.—With vegetables we have a very wide range of storage troubles. In the case of potatoes we have two general types of rots, namely: wet-rot and dry-rot. The wet-rot of potatoes commonly result from two causes, viz.: The late blight or rot fungus (*Phytophthora infestans* D'By.) may be expected to cause considerable losses of the tubers in storage when these have been gathered from Phytophthora infested fields and bacteria may cause rot in injured tubers. In Ohio, as stated under this disease of potatoes, the late blight and rot fungus is not commonly prevalent. Perhaps little can be done to preserve the tubers from such fields except to market the crop promptly and to store with especial respect to the optimum conditions. The best temperatures for such potatoes will be warmer than for apples, and it is very desirable that moisture be kept as low as possible.

A wet-rot of potatoes, purely or very largely bacterial in cause, must also be dealt with. This rot bacterium is different from the bacterium of potato wilt (*Bacillus solanacearum*) and without the latter may also induce considerable decay. It is believed the bacteria producing this wet-rot gain entrance through injuries to the tubers and that low humidity—dry storage—is especially desirable in keeping down losses from this source.—(Ohio E. S. B. 214.)

Dry-rot of potatoes is due to a fungus (*Fusarium oxysporum*) which appears to belong among our soil infesting fungi. This fungus appears to be the cause of premature dying of the potato plants and it certainly survives in the tubers from such infected plants. At harvest time, as shown under dry-rot of potato, tubers show infection at the stem end. Subsequently during storage the fungus penetrates more deeply into the tubers and will often produce dry-rot of the infected tubers. Further descriptive matter concerning dry rot will be found in the special part of the bulletin under potato. For storage of such infected tubers, as well as for the general crop, it is desirable that storage temperatures be kept about 42 degrees Fahr., or slightly lower.

Sweet potatoes also suffer from a large variety of rot troubles. These sweet potato rots are more or less special in character and since the crop is not largely handled in cold storage, nothing is here offered in addition to what appears in the special part of the bulletin.

Onion Rots in Storage.—Onion rots are a serious matter with onion growers and onion dealers as well. It has been found that particular varieties of onions in our climate are susceptible to special diseases. For this reason we must consider white onions such as White Silverskin, White King, etc., in a separate class from the rots of red and yellow onions such as the Globe and Wethersfield varieties.

With the white onions the problem is partly a field problem at harvest time, and partly one of storage. The growers are in the habit of gathering the white onions before the tops fall, and topping them immediately, instead of throwing together in heaps for absorption of the substance of the tops by the onion bulbs as is practiced with the riper red and yellow varieties. After topping the white onions are placed in slatted crates, and these crates are stacked in the field or in open sheds where they are kept dry. Often the loss from rot during the six weeks following harvest may reach 60 per cent of the crop and as shown by investigations in Connecticut and our own state, it has not always been clear why these losses are so large. Recent investigations by this department lead us to believe that the green onion neck of white onions handled in this way affords entrance for the organism of the rot.

The sclerotium rot (*Sclerotium cepivorum*) appears to be the most serious, although smudge or anthracnose of the onion (*Vermicularia circinans*) may sometimes cause large losses. Both these rots are described under diseases of the onion. The writer believes the Sclerotium rot is the larger criminal, and that both may be handled by disinfection of the onions immediately after harvest. This disinfection may be carried out as described under the Maine formula for Formaldehyde Gas Treatment, which is:

Commercial 40 per cent Formaldehyde....... 3 pounds.
Potassium Permanganate crystals............23 ounces.
Sufficient for 1,000 cu. ft. of space occupied by crates or trays.

The object of immediate disinfection is to prevent the entrance of these organisms, particularly the sclerotium rot, through the green neck of the newly topped onions. The exuding juices offer favorable culture conditions for the fungus to develop.

When no fumigation is practiced following harvest, the onions which are found to be sound and delivered for storage at the close of the season may very profitably be treated in this way before winter storage. Both these rots are essentially dry-rots of onions. In addition, sometimes, we have wet-rot of white onions which may be either due to bacteria or to the same fungus as the wet-rot of Globe or other onions mentioned below.

The rots of yellow and red onions are of both the wet-rot and dry-rot types, but the wet-rots are much more serious with these varieties. Doubtless, as in all vegetables held for a long time in storage, we have many cases of wet-rot in onions where some of the common decay bacteria are the chief cause. These find entrance through wounds, as in topping, and, under conditions favorable for their development invade the tissues of the onion and cause decay.

In addition, however, to the wet-rots due to bacteria of undetermined species, we have a specific wet-rot of onions due to Fusarium species. This wet-rot fungus belongs to the same group as the potato dry-rot and is liable to infect soils in which onions are grown year after year. Rotted onions will show external developments of the pink fungus and may be detected in that way as well as by use of the microscope. The chief factors of control with onions of this kind, are in the methods of culture followed to produce the crop.

Dry-rot of red and yellow onions is rather rare and is commonly referable to the anthracnose or Vermicularia dry-rot fungus described under white onions. The best temperatures for onion storage are about 38 to 42 degrees.—(Ohio E. S. B. 214.)

INSECT CONTROL MEASURES.

REMEDIES FOR PLANT DISEASES—FUNGICIDES.

In no other line of applied science has America made more rapid progress than in the matter of plant disease remedies. While the general doctrine of parasitism and the transmission of parasitic diseases are thoroughly investigated and widely published in Europe, the application of remedies and the interest in disease prevention fall much behind the practices in America. Possibly this great progress is due to the greater readiness with which Americans engaged in crop production, accept the teachings of scientists and make practical applications of the results obtained. Among remedies for plant diseases we must include all treatments which tend to restrict or prevent the recurrence of diseases, that is, all treatments which remedy infections or limit the spread of parasitic attack.

Seed and Soil Treatment.—In the seed treatments high temperatures, as in the hot water, or the application of a germicide as in solutions of formaldehyde are applied to the seed grain to destroy adhering spores. In the treatment of tubers and roots as the potato, etc., longer soakings with solution of formaldehyde or corrosive sublimate are required to kill not only external spores but resting forms of fungi such as sclerotia, etc.

With soil treatments we have the problem of killing out soil infesting organisms such as nematodes or eelworms and Rhizoctonia, Botrytis, lettuce drop, etc., among the fungi. All these results are obtained by thoroughly steaming the soil. In a measure the same results are also obtained from a formaldehyde drench as elsewhere described.

Fumigation for the destruction of seed infesting fungi or cutting infesting insects is of the same character and must be named here. The fumigation of nursery cuttings with hydro-cyanic gas is effective as is also the fumigation of stored grain with carbon bisulfid. We must also consider that wound coverings are methods of prevention in plant disease, since these coverings of asphaltum creosote, gas tar, paraffine and even of paint serve the purpose of excluding wound fungi which might otherwise cause serious decays. All these treatments that have just been enumerated apply to the treatment of the soil or of seeds and plants in resting condition. The great problem of keeping down infection during the growing period yet remains for the application of spray mixtures.—(Ohio E. S. B. 214.)

HOW TO OBTAIN SUCCESS IN SPRAYING.

Success in spraying is to be secured only by careful attention to details in two principal directions: (1) Sprayings must be timely, and the proper time varies with the particular conditions. The operator should know what disease or diseases he is expecting to prevent by the application of the spray, and should thoroughly post himself beforehand as to the correct times and intervals for spraying for that particular disease. The spray must be applied ahead of the infection periods of the fungi. (2) The spraying should be thoroughly done. In dormant spraying a coarser spray can be used than in summer spraying, because the object is merely to form a complete coating of the spray over the wood. In summer spraying, however, an exceedingly fine, mist-like spray reaching every portion of the plant and covering with minute dots, preferably no larger than a flyspeck, every square inch of the fruit and foliage is necessary. It is not necessary that the minute specks of the spray should entirely coalesce into a coating, although where a second or third treatment is made this often results. But there should be no spaces the size of one's thumb nail not thoroughly peppered with the spray.—(F. B. 243.)

COPPER COMPOUNDS.

Formulas for Bordeaux Mixture.—The most valuable fungicide for use in combating plant diseases is Bordeaux mixture, consisting of a mixture of copper sulphate (bluestone) and stone lime slaked in water. The formula varies somewhat according to the use which is to be made of the spray. Following are the ones most used:

Standard Bordeaux Mixture.—The following formula, known as the 6-4-50 formula, the ingredients being mentioned always in the same order, is used in the preparation of the standard Bordeaux mixture:

Copper sulphate (bluestone)	6 pounds
Lime	4 pounds
Water to make	50 gallons

This mixture can be used successfully on many plants, but on others, like the peach and Japanese plum, it injures the foliage. It also sometimes russets the fruits of apples and pears. It can be increased in strength for certain purposes by reducing the proportion of water, but the formula given above has been regarded as the standard with which all others should be compared, at least in experimental work.

The 5-5-50 *Formula.*—Standard Bordeaux mixture is frequently slightly modified, a very common modification being made according to the formula which follows:

Copper sulphate	5 pounds
Lime	5 pounds
Water to make	50 gallons

The use of this formula is desirable where the purity of the lime is in doubt, as it makes certain, with lime of any reasonable quality, that all of the copper is properly neutralized. The danger of scorching or russeting the fruit is therefore less. Withholding 1 pound of copper sulphate also cheapens the mixture by a few cents. For these reasons the 5-5-50 formula has come to be quite generally used in orchard spraying. In fact, it has almost replaced the old standard Bordeaux mixture in spraying for the apple scab, bitter-rot, pear and cherry leaf-blight, and similar diseases. In the central

Mississippi Valley the 4-5-50 formula has given good results, especially in dry years.

The 4-4-50 and Other Formulas.—The strength is often still further reduced by using a 4-4-50 formula, but it is questionable whether it pays to reduce the strength. The same result can be secured with sprays having less copper, provided the application is thorough and repeated; but, as in actual experience the cost of applying Bordeaux mixture is often from two to five times the cost of the mixture itself, economy demands the use of the strongest mixture which will do the work without injury to the plants. For use as a whitewash, a very concentrated mixture, 6-4-20, may be desirable; and for certain diseases Bordeaux mixture can be diluted so as to be equivalent to 6-4-100.

Peach Bordeaux Mixture.—The form of Bordeaux mixture most harmless to foliage is made up by the formula 3-9-50, having a considerable excess of lime. This may be known as peach Bordeaux mixture, and contains ingredients as follows:

Copper sulphate	3 pounds
Lime	9 pounds
Water to make	50 gallons

Modified Bordeaux Preparations.—Various modifications of the original Bordeaux mixture have been suggested and tried. The principal ones, however, are the soda Bordeaux mixture and the potash Bordeaux mixture. The former consists of 6 pounds of copper sulphate, 2 pounds of caustic soda, and 50 gallons of water. The latter is the same except that an equal quantity of caustic potash is substituted for the soda. Other materials are sometimes added to Bordeaux mixture to increase its spreading power. The most successful is ordinary hard soap, dissolved in hot water and added at the rate of 4 pounds to the barrel, and this modified Bordeaux mixture is known as soap Bordeaux.—(F. B. 243.)

Method of Making Bordeaux Mixture in Small Quantities.—Where only a small quantity of Bordeaux mixture is required—from a bucketful to a barrel—gives good results. Two half-barrel tubs are made by sawing a barrel through the middle. One tub is used for the bluestone solution and the other for the milk of lime, and each tub should contain 23 to 25 gallons. One man dips the bluestone solution with a bucket and pours it into a barrel or other vessel, and another man simultaneously dips up and pours in bucketfuls of the milk of lime. The lime solution should be kept well stirred. If only a single barrel is to be made, the materials may be dissolved in the dilution tubs, but if a number of lots are required the materials can be kept in stock solution and simply transferred by dipping. In preparing very small quantities of Bordeaux mixture, buckets of similar vessels may be substituted for the half-barrel tubs. It is possible for a single operator to dip a bucketful of the bluestone solution and then a bucketful of milk of lime and pour them together into a vessel. It is usually preferable to have a bucketful or so of water in the receptacle into which the solutions are to be poured, but this is not essential.

The better and quicker way of making up Bordeaux mixture by the barrel consists in placing the two half-barrel tubs on an elevated platform and then, by means of hose or spigots, allowing the two solutions to flow together into a barrel.

Straining the Materials.—No matter what quantity of mixture is to be made up, it is necessary to strain the materials through a wire strainer. The best type of strainer is made of brass wire, with 18 or 20 meshes to the inch. If all the copper solution is strained and then the milk of lime is strained into the dilution vessels, it will not be necessary to strain the Bordeaux mixture as, on account of its flocculent character, it is sometimes more difficult to pass through the strainer than the lime milk. Some very good strainers made of copper are on the market and may be obtained from the makers of spray pumps. One of the best, which can be made at home, is in the form of a box about a foot square, the bottom of which is a rather heavy board (preferably of hardwood) with a hole bored through it, into which a piece of gas pipe 1½ to 2 inches in diameter and 8 to 12 inches long is fitted. The box is of course open at the top. Fitting just inside this box is a second and lighter box, also open at the top, and having an overhanging strip nailed around the top which supports it. The bottom of this inner box should be made so as to slope at an agle of about 30°, and should be made of wire screen. The slanting bottom makes it harder to clog with the spray, and the inner box, being movable, can be inverted and washed in a tub of water.

Method of Preparing Bordeaux Mixture for Large Operations.—In large operations stock solutions should always be used, as the time required to dissolve the material is saved.

Stock Solutions.—These can be prepared of both the copper sulphate and the lime. They may be made by dissolving copper sulphate in water at the rate of 1 pound per gallon, and lime in the same ratio, although a strength twice as great may be used in warm weather. When stock solutions are on hand it is only necessary to measure off the required quantity of each and dilute with water before mixing. In preparing a stock solution of copper sulphate, a 50-gallon barrel may be filled about two-thirds or three-fourths full of water; then a sack, or a box with perforations over which copper wire has been tacked, containing 50 pounds of bluestone, should be suspended in the upper part of the barrel and enough water added to fill the barrel. In from twenty-four to thirty-six hours this material will be entirely in solution, and the sack or box may be removed. A slight stirring will insure the even distribution of the bluestone, after which the solution is ready for use.

The copper sulphate should be measured in a copper or graniteware receptacle, iron or tin vessels being quickly destroyed by either copper sulphate or Bordeaux mixture.

Use of an Elevated Platform.—If possible the dilution tanks should be raised so high on an elevated platform that the mixture can be conducted by gravity directly into the spray tank beneath. If a hillside is available, it is much the most convenient place to do the work. The platform can be arranged with a roadway on its upper side so that the lime and bluestone can be delivered there, while the spray tank is filled from the lower side.—(F. B. 243.)

The Water Supply.—A water supply of some sort is necessary; a tank filled by a windmill pump and elevated so as to be a few feet above the dilution tanks is a great advantage. Hose may be used to fill the dilution tanks, or an iron pipe with a spigot may be placed over each tank. Each dilution tank should hold half the quantity it is desired to make up at one time—that is, if a 200-gallon spray tank is to be filled the dilution tanks must hold about 100 gallons each. There is no objection to adding a few extra gallons of water, but it is better to have the tanks hold just the right quantity.

Methods of Mixing the Solutions.—Either of two methods of mixing can be employed: One in which the spray material is conducted directly from the dilution tanks into the spray tank and actually mixed in this tank; the other in which a mixing tank sits just below the dilution tanks and from which the spray, after being mixed up, is conducted by gravity into the spray tank. In certain ways the latter is more convenient than mixing directly into the tank, but unless the operations are somewhat extensive it will hardly justify the extra expense. In very large operations, however, a separate mixing tank is recommended—or perhaps even two of them side by side—so that batches of the mixture can be kept on hand for a few moments awaiting the spray wagons.

Testing Bordeaux Mixture.—When Bordeaux mixture is properly prepared it is of a brilliant sky-blue color. If the lime is air-slaked or otherwise inferior in quality, resulting in a bad mixture, the preparation will have a greenish cast, and if this is very pronounced, the mixture will injure the foliage.

In order to make certain that the copper sulphate is properly neutralized by the lime, the yellow prussiate of potash test may be used. A small bottle containing a 10 per cent solution of yellow prussiate of potash can be secured from a druggist. After stirring the Bordeaux mixture, a drop of this solution is allowed to fall on the surface of the preparation. If free copper is present, the drop will immediately turn reddish-brown in color. Lime should then be added until the brown color fails to appear. If the reaction is complete, the yellow prussiate of potash solution will remain a clear yellow until it disappears in the mixture.

Adding Insecticides.—One advantage of Bordeaux mixture is the possibility of adding arsenical insecticides to the preparation and thus of spraying at the same time for diseases and for the codling moth and leaf-eating insects. Paris green, at the rate of one-quarter pound to 50 gallons of Bordeaux mixture, may be considered as the standard formula for this purpose. London purple, arsenate of lead, and other arsenicals may be used in the same way. Bordeaux mixture may be considered as so much water in the formulas for this class of insecticides. As a matter of fact, the slight excess of lime in the standard mixture renders it an especially suitable medium for distributing these insecticides.

Dust Bordeaux Mixture—Formula.—The formula given by Mr. W. M. Scott, of this Bureau, for dust Bordeaux mixture and the method of preparation are as follows:

4 pounds of copper sulphate in 4 gallons of water.
4 pounds of lime in 4 gallons of water.
60 pounds of slaked lime dust.

Dissolve the 4 pounds of copper sulphate in 4 gallons of water and slake 4 pounds of lime in 4 gallons of water. When cool pour the two solutions together simultaneously into a tub. Allow the resulting precipitate to settle, decant off the liquid, pour the wet mass of material into a double flour bag, and squeeze out as much water as possible. Then spread out the dough-like mass in the sun to dry. After a day's drying it can easily be crumbled into an impalpable powder by crushing with a block of wood or even with the hand. This powder should be screened through a sieve of brass wire having at least 80 meshes to the inch and should then be thoroughly mixed with 60 pounds of slaked lime dust.

The lime dust is best prepared by slowly sprinkling a small quantity of water over a heap of quicklime, using barely enough water to cause the lime to crumble into a dust. The heat generated will soon drive off the excess of moisture, and the dust should then be passed through a screen of 80 meshes to the inch. This powder is usually applied by means of a blower. If desired, 4 pounds of sulphur and 1 pound of Paris green may be added to each 60 pounds of Bordeaux mixture dust.

Finely powdered copper sulphate, used with lime as a conveyer, is also sometimes applied to plants. When so employed at least 15 pounds of slaked lime dust should be used to each pound of copper sulphate, as this will make a pretty strong fungicide. The manufacturers of dust sprayers have on the market several ready-made preparations. As a rule, these do not contain as much copper sulphate as is recommended in the above formula.

Value of Dust Sprays.—The expense of handling large quantities of water in making up the liquid Bordeaux mixture has deterred many orchardists from using it. In case of certain mountain orchards, it is not practicable to haul the water up the steep hills or mountain sides, nor is it feasible to drive between the tree rows with heavy spraying tanks. There is a very urgent demand, therefore, for successful dry fungicides to be applied without the use of water, as the weight of the material handled is very much reduced. So far, however, in the treatment of apple scab, bitter-rot of the apple, pear leaf-blight, black-rot of the grape, and other fungous diseases requiring careful spraying, the dust method may be regarded as still in the experimental stage and of doubtful value. It is not to be compared with properly made Bordeaux mixture applied as a spray in the treatment of these diseases. In the treatment of the codling moth, however, better success has been obtained, and some help may be expected against fungi. Mr. Scott's formula is the result of considerable experimenting, and it is recommended as the best one to use. The writer is not able, however, to recommend dust spraying for general use, and wherever liquid spraying is practicable it should by all means be used.

FORMULAS FOR OTHER COPPER SOLUTIONS.

Copper Sulphate Solution.—The formula for copper sulphate solution is as follows:

Copper sulphate (bluestone)	3 pounds
Water	50 gallons

Dissolve the bluestone in the water in the same manner as for the preparation of Bordeaux mixture (p. 657). A more dilute solution (2 pounds to 50 gallons) is sometimes used on foliage.

Caution.—This solution is severely injurious to plants in foliage, and should therefore be applied only during the dormant period. Even the more dilute solution is usually injurious to leaves and flowers.

Copper Acetate Solution.—The following formula is used for copper acetate solution:

Dibasic acetate of copper.....................	6 ounces
Water	50 gallons

Copper acetate is readily soluble in water, and the solution may be effected by simply adding the salt to the water and stirring thoroughly. Its use is much the same as that of ammoniacal copper carbonate, and it is recommended for application to ripening fruit when it is desired to avoid the staining effect of Bordeaux mixture, though it is much inferior to the latter as a fungicide.

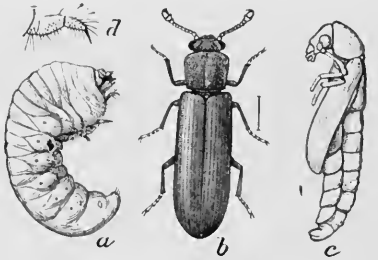
Caution.—The injurious effect of acetate of copper on foliage is somewhat greater than that of Bordeaux mixture, and to such susceptible foliage as that of the peach it should be applied sparingly, if at all.

Ammoniacal Copper Carbonate.—The formula for ammoniacal copper carbonate is as follows:

Copper carbonate	5 ounces
Strong ammonia (26° Baumé)	2 to 3 pints
Water to make..........................	50 gallons

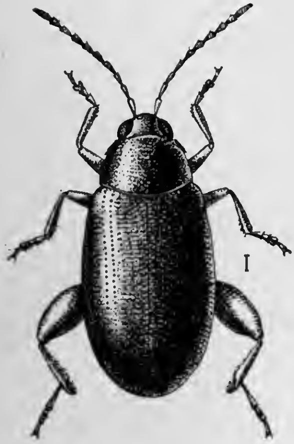
Dilute the ammonia with about 2 gallons of water, as it has been found (Penny, Del. Exp. Sta. Bul. 22) that ammonia diluted seven or eight times is a greater solvent for copper carbonate than the concentrated liquid. Add water to the carbonate to make a thin paste, pour on about half of the diluted ammonia, and stir vigorously for several minutes; allow it to settle and pour off the solution, leaving the undissolved salt behind. Repeat this operation, using small portions of the remaining ammonia water until all the carbonate is dissolved, being careful to use no more ammonia than is necessary to complete the solution. Then, after adding the remainder of the required quantity of water, the solution is ready for application.

Ammoniacal copper carbonate is a clear, light-blue solution, which upon drying leaves little or no stain. As a fungicide it is inferior to Bordeaux mixture, and should be used only as a substitute for the latter when the stain of Bordeaux mixture upon ornamental plants and maturing fruits is objectionable.



POWDER POST BEETLE. *A.* LARVA. *B.* ADULT. *C.* PUPA. *D.* LEG OF LARVA. DEPT. OF AGR.

(See pages 316 and 368.)



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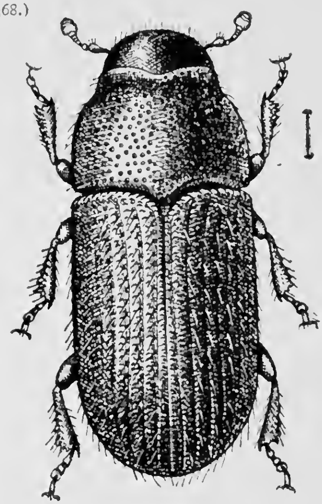
HOP FLEA BEETLE. DEPT. OF AGR.



DENDROCTONUS ADULT. LOG AND BARK INSECT. DEPT. OF AGR.

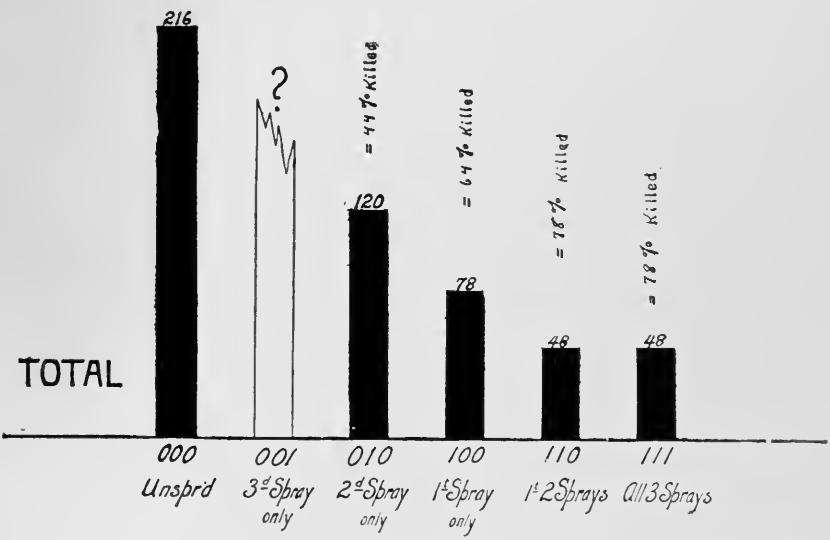


CHART TO ILLUSTRATE RELATIVE VALUE OF EARLY SPRAYINGS ON THE SECOND BROOD OF WORMS OF CODLING MOTH. DEPT. OF AGR.

Caution.—Plants likely to be injured by Bordeaux mixture are susceptible to more severe injury from applications of ammoniacal copper carbonate. This solution should therefore be applied to such plants with caution, if at all.

Eau Celeste (Modified).—The following formula is used for a solution of eau celeste:

Copper sulphate	4 pounds
Ammonia	3 pints
Sal soda	5 pounds
Water to make	45 gallons

Dissolve the copper sulphate in 10 or 12 gallons of water, add the ammonia, and dilute to 45 gallons; then add sal soda and stir until dissolved. Eau celeste is an effective dormant spray for the peach leaf-curl and other similar diseases, but it is unsafe to use on the foliage of most plants.—(F. B. 243.)

Caution.—This wash should not be used on the foliage of stone fruits, and should be applied to other growing plants only with due caution.

Sulphur and Resin Solution.—The mixture known as sulphur and resin (sar) solution is made up as follows:

Sulphur (flowers or flour)	16 pounds
Resin (finely powdered)	½ pound
Caustic soda (powdered)	10 pounds
Water to make	6 gallons

Place the sulphur and resin, thoroughly mixed, in a barrel or smaller vessel and make a thick paste by the addition of about 3 quarts of water. Then stir in the caustic soda. After several minutes the mass will boil violently, turning a reddish brown, and should be stirred thoroughly.

After boiling has ceased add about 2 gallons of water and pour off the liquid into another vessel and add to it sufficient water to make 6 gallons. This form of stock solution may be used at the rate of 1 gallon to 50 of water for spraying most plants and for soaking seeds.

Potassium Sulphid.—For a fungicide of potassium sulphid the following formula may be used:

Potassium sulphid (liver of sulphur)	1 ounce
Water	3 gallons

Dissolve the liver of sulphur in the required amount of water and use immediately. On standing the mixture deteriorates rapidly. It is effective for surface mildews, such as gooseberry mildew.—(F. B. 243.)

Sulphur.—This is used as a fungicide in a pure state. It is on the market in a number of different commercial grades. The "flowers" of sulphur is the lightest and usually the purest chemically. The "flour" of sulphur, while finely divided, is not so light. It is sold in different degrees of fineness and purity. Stick sulphur is the same material in a solid stick. Flowers of sulphur dusted on plants is useful as a remedy for mildew, especially the rose mildew and the powderly grape mildew.

The heating pipes of greenhouses are frequently painted with flour of sulphur made into a paste with water for the production of fumes, which act to prevent various diseases. Fumes from burning sulphur may be used to disinfect empty greenhouses, storage houses, and outbuildings.

Caution.—Fumes from burning sulphur are destructive to plant life and should never be used to disinfect inclosures containing live plants or fresh fruits and vegetables, as they will kill them wholly or in spots.

Corrosive Sublimate.—Corrosive sublimate (mercuric chlorid) is used at the rate of 1 part to 1,000 parts of water to disinfect the knife or other tools used in cutting out pear-blight. Convenient-sized tablets of this substance can be purchased at a drug store and kept in a bottle. One of these tablets may be added to a bottle containing the required quantity of water (usually a pint), and a sponge or cloth saturated with this solution may be used to wipe the tool after each cut. It is also advisable to disinfect in this way the wound made by the removal of the blighted wood.

Caution.—Taken internally, corrosive sublimate is a deadly poison and should be handled as such.

DIRECTIONS FOR THE PREPARATION OF SELF-BOILED LIME-SULPHUR WASH.

The standard self-boiled lime-sulphur mixture is composed of 8 pounds of fresh stone lime and 8 pounds of sulphur to 50 gallons of water. In mild cases of brown-rot and scab a weaker mixture containing 6 pounds of each ingredient to 50 gallons of water may be used with satisfactory results. The materials cost so little, however, that one should not economize in this direction where a valuable fruit crop is at stake. Any finely powdered sulphur (flowers, flour, or commercial ground sulphur) may be used in the preparation of the mixture.

In order to secure the best action from the lime, the mixture should be prepared in rather large quantities, at least enough for 200 gallons of spray, using 32 pounds of lime and 32 pounds of sulphur. The lime should be placed in a barrel and enough water (about 6 gallons) poured on to almost cover it. As soon as the lime begins to slake the sulphur should be added, after first running it through a sieve to break up the lumps, if any are present. The mixture should be constantly stirred and more water (3 or 4 gallons) added as needed to form at first a thick paste and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

The stage at which cold water should be poured on to stop the cooking varies with different limes. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot for 15 or 20 minutes after the slaking is completed, the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through the strainer.—(F. B. 440.)

HOW TO PREVENT SMUT IN GRAIN.

Smut in wheat and oats causes serious loss to Wyoming grain growers. Sometimes the loss amounts to two-thirds or three-fourths the entire crop, and in such instances the small amount of grain obtained has little market value. The trouble is easily overcome, and it is dollars in the pocket of every man who raises wheat or oats to treat his seed to prevent the disease. It costs from two cents to five cents per bushel, or from four cents to ten cents per acre, to treat the seed. Where the treatment is properly and carefully done the resulting crop may be increased in value from four dollars to eight or more dollars per acre.

Smut is caused by tiny black or brown spores which cling to the seed, or which may remain in the ground over winter. When the seed germinates the spores also grow, and send a minute thread up in the grain stalk to the head, where it destroys the kernels of grain, producing spores instead. Anything which will kill the spores on the seed without injuring the germination of the grain will improve the quantity and quality of the crop, providing the treated seed is planted on land which has not grown smutty grain for one or two years. We recommend any one of the following four methods:

Jensen Hot Water Treatment.—This is generally recommended as the best method. You must have a good thermometer to test the temperatures. The water may be heated in any convenient way. Have the water in one barrel or tub at a temperature of 125° to 130° F., and in the second barrel at a temperature of 132½° to 133° F. Put the grain in a wire basket or gunny sack, having it only partly full, so that the grain can be all shaken apart when in the water. Dip into the first barrel for three or four minutes to thoroughly warm it. Then dip it at once into the second barrel, subjecting the grain to the temperature of 132½° to 133° for ten minutes, shaking about so all the grain will become warmed to the temperature of the hot water. Lift out of water, drain and spread out to dry before sowing. Be very careful with the temperature of the water. If it goes above 134° or 135° the grain will be injured, and if the seed treated is not heated to 132° the spores will not be killed. Do not leave in the water more than ten minutes. Have eight or ten times as much water as the amount of grain dipped at a time and have hot and cold water at hand to add, in order to keep proper temperature while grain is being dipped. [Send for Wyo. Exp. Sta. Bull. 21.]

Copper Sulphate or Blue Stone.—a. Dissolve one pound copper sulphate in 5 gal. water by hanging a sack containing it in the top of a barrel or tub until the sulphate is all dissolved. Dip the grain in this solution for two or three hours and then spread out to dry.

b. A safer method.—Dissolve one pound copper sulphate in 20 gal. water and let grain soak 12 hours. Then dip in solution of one pound lime to 10 gal. water for five or ten minutes and spread out to dry.

Potassium Sulphide for Oats.—a. Dissolve 2 pounds potassium sulphide in 20 gal. water and soak seed 10 or 12 hours. Then dry so the oats can be planted with drill or otherwise.

b. Dissolve 1 pound potassium sulphide in 20 gal. water and soak the oats 24 hours, and dry. This is an excellent method.

Formalin for Wheat or Oats.—a. Pile the grain on a floor where it can be shoveled over or stirred. Mix one pound of Formalin (Formaldehyde) in 50 gal. water and sprinkle over the grain with a hand or garden sprinkler, stirring the grain until it is all wet.

b. Mix one pound of formalin with 100 gal. water and dip the grain in it until it is thoroughly saturated. Spread out to dry or plant at once. Formalin must be used with great care for if used in too strong solution or the grain left in too long it will destroy its germinating power.

General Caution.—In our experiments we have found that the germinating power of seed wheat or oats raised at high altitudes is quite easily injured. In treating it more than ordinary care must be taken. In using above methods with grain raised above 6,500 feet altitude, be sure that the water does not get too hot, and do not soak more than eight or ten minutes. With other treatments use the weaker solutions, and do not soak the seed more than twelve to twenty hours.—(Wyo. Press Bul. 15.)

THE LIMITS IN SEED TREATMENT.

It will be apparent that serious limits hold in regard to seed treatments. Where the spores are external and simply adhering to the seed grain, treatment will destroy these spores if rightly adapted to the seed in question and the germination need not be much, if any impaired. On the other hand where the seed infection is internal rather than external, grave doubts arise as to the possibility of successful seed treatment. It has not been found possible in the cases of seed peas when infected with the blight fungus, or of seed wheat, rye, etc., infected with the scab and other fungi to apply any seed treatment which would destroy the infecting fungus without destroying the vitality of the seed grain. In general we may say that where the seed infection or fungus spores, etc., are external to the visible or germinable grain, seed disinfection through treatment is possible, but for the internal fungi it is rarely possible. The loose smut of wheat may be amenable to special seed treatment with only partial loss of vitality in the seed wheat.—(Ohio E. S. B. 214.)

Potato Disease and Treatment of Seed.—There can be no doubt that the success of the potato crop depends very much on the condition of the seed. Our experiments indicate that treatment of the seed, if it be carefully done, will prove highly profitable. The average grower does not realize as great profit from his potatoes as he might. There are too many failures; too many instances of only partial crops, and too many potatoes put on the market which are scabby or otherwise imperfect.

About two years ago Prof. F. M. Rolfs of the Colorado Experiment Station discovered the cause of many of our potato failures, and his study since that time has been of great value to the potato grower. The troubles which are often called blight, collar or crown rot, black ring, and little potatoes, are due to a disease which is caused by a fungus, known as *Rhyzoctonia.* This fungus grows on a dozen or more different kinds of plants, and does serious injury to several of our more important agricultural crops. It was first discovered on alfalfa and clover roots in Europe nearly ninety years ago, but the first account of its appearance in this country was published by the Cornell and Geneva Experiment Stations in 1901. So serious is the pest on potatoes in the West, that it not only decreases the potato crop thousands of dollars' worth every year, but over large areas farmers make few attempts to raise potatoes at all, under the impression that their soil is such that it is impossible to grow profitable crops.

In our potato regions it is necessary to change seed every two or three years, in order to get that which is more free from the disease or more able to resist its attack. Two years ago potato crops failed generally over a large portion of the West. The cause was not apparent, but it is now believed that the season was especially favorable to the growth of this fungus.

The fungus grows on the potatoes themselves, producing rough, cracked, corky skins, but the principal damage is done by its attack on the young sprouts. It either kills them before they come up, causing poor stands of plants, or affects the growing vine in such a manner that the root-stalks, upon which the young potatoes set, are either cut off or the vine is deprived of nourishment, so the tubers which do set on, remain small. The effect on the vines is often called blight. The fungus remains over winter in the soil, and also on the potatoes themselves, where it is easily seen in the brown or black spots which look like particles of soil, and these are difficult to remove, but when rubbed open they look something like smut of the wheat kernel.

If potatoes are grown on soil which has become affected with the fungus, little can be done, though Rolfs found that after the vines showed blight, spraying with Bordeaux mixture increased the crop. It is believed that the fungus will live at least three years in the soil, and be ready to produce the disease on potatoes planted therein.

Dissolve two ounces of corrosive sublimate in two gallons of hot water, and mix this with fourteen gallons of water in a barrel. This gives a solution containing one ounce of corrosive sublimate in eight gallons of water. Soak the potatoes in this solution for one and one-half hours, after which spread out in the sun to dry before they are cut for seed. This treatment not only kills the *Rhyzoctonia* fungus, but it also destroys the fungus which produces potato scab and protects the seed potatoes from rotting in the soil, should sprouting be delayed by long continued wet or cold weather.

In the experiments of the Wyoming Station, we found that treating the seed with corrosive sublimate greatly increased our crop. Care must be taken in using this treatment, because corrosive sublimate is a deadly poison. It must be used in wooden or earthenware vessels, and these, or the sacks in which the potatoes are placed, must not be used for any other purpose. The solution must not be too strong, nor the potatoes soaked longer than the time stated, because it is apt to kill the potato sprouts, or make them very slow to come up. —(Wyo. Press Bul. 16.)

After soaking the seed, it should be treated with sunshine for a few days, and cut not more than a day or two before planting. Our best results have been obtained by planting small potatoes whole, or by quartering the potato lengthwise, leaving a part of the seed-end on each piece. Plant a liberal amount of seed.—(Wyo. E. S. B. [Press] 16.)

RESISTANT VARIETIES IN THE CONTROL OF PLANT DISEASES.

The subject of resistant or immune varieties in the control of plant diseases has recently become a prominent one with plant pathologists and with many cultivators. It is easy to see what great interest it has to those working to keep our crops in health and productiveness for if we can grow crops that are not subject to the common ailments that so reduce the yield annually and periodically almost entirely wipe out a crop; then all the great trouble of spraying and all other methods and anxieties for crop protection are entirely done away with.

Undoubtedly most of you have noticed years ago that some varieties of fruits or vegetables rot, or blight worse than others, or what is a closely related phenomenon familiar to all, some varieties are injured by frost much more easily than others and some are more subject to drouth injury than others, that is, some are hardy and others are not. Several years ago, so called immune varieties were put on the market and we had rust-proof oats and blight-proof pears, and while they may have been less subject to these diseases, experience soon proved that they could not be called proof or immuned from them.

The theory of immunity and infection in plants (as well as animals) as stated by Prof. Ward and other prominent authorities and supported in fact, at least with certain rusts on grasses, by numerous experiments by Prof. Ward is about as follows: Infection depends on the power of parasites by means of toxins or enzemes that they produce to overcome the living plant upon which they may be growing, and so feed upon it. Resistance or immunity depends upon the power of the host plant to form anti-bodies (or antitoxins) which destroy such toxins or enzemes or to excrete chemotactic substances which repel fungus protoplasm.

The work of Ward and others indicates the great probability that the hindrance to attack by fungus spores or bacteria in plants which remain healthy under infection conditions is not in any sense a mechanical one depending on the size or number of breathing pores, thickness of epidermis, hairyness, &c., but resides in the peculiarities of the protoplasm and is in no sense different from the conditions that render animals immune to disease. It would then seem possible if difficulties in technique did not stand in the way to vaccinate plants or introduce protective serums that would immunize them against disease.

The principle that I have stated would indicate that if plants can be bred that are active in producing the anti-bodies and so overcoming parasites, fungi can also develop that will overcome the new varieties, since the fungi are only small plants, and subject to the same general laws of plant life. Another possible hindrance to securing disease resistant varieties is that the very characters in certain varieties that make them desirable may be the same that would favor disease.

It seems to me very probable that we shall be able to obtain strains of most of our crops, resistant against all diseases produced by parasites that confine themselves to particular species. I think it much less probable that we shall be able to get varieties resistant to such diseases as some of the sclerotinia troubles and mildews that attack indiscriminately a number of different kinds of crops.

A great deal of practical work has already been done in selection of varieties less subject to diseases, and recently much attention has been given by plant breeders to the securing of disease resistant crops. It may be of some practical value to you to mention some of this work though in the limited time I cannot do more than give some examples of what is being done. Much has been done by observation on disease resistance while breeding plants for other purposes.

Prof. Hanson, of South Dakota, one of the leading plant breeders of America, in producing hardy fruits for the cold Northwest has found mildew resistant forms of the sand cherry, one of their promising fruits and is working for a strawberry, whose leaves will not rust. Hanson also noted an interesting fact regarding mildew. Some of the wild roses subject to mildew, produced mildew free hybrids with cultivated ones.

J. B. Norton in his work in producing new varieties of oats has noted the variation with respect to smut in the product of his crosses and one good production is practically free from smut, a disease which causes hundreds of thousands of dollars loss annually in the West.

On the other hand selection and breeding of disease resistant varieties has resulted in securing forms valuable in other ways. Carleton's efforts to get wheat varieties that would not be seriously injured by rust, have resulted in the introduction of drouth resistant wheats, some of which also have a minimum of rust and have been the means of opening up millions of acres to wheat culture which were practically unused before.

Orton's work with cotton, watermelon and cowpea root diseases, so destructive in the South, is another example of practical disease resistance breeding. He has found, or produced varieties which will bring a crop where the ordinary kinds would fail, and in case of the watermelon, the new variety is a cross with the disease resistant citron melon, worthless from the watermelon standpoint, yet the new form combines with resistance all the good qualities of the watermelon.

Jones, of Vermont, also has tested and selected from the great variety of potatoes a number of kinds resistant to scab and blight. A Colorado man has published accounts of a blight resistant cantaloupe. Some of the new alfalfas introduced by the United States Department of Agriculture, are proving to be only slightly attacked by the leaf-spot, which is one of the worst alfalfa foes.

A tabulation has been given in New York and Nebraska Experiment Station Bulletins of the relation of apple varieties to scab. And while they do not agree entirely, a few varieties that were found resistant are given: Oldenburg, resistant in both States; wealthy, resistant in Nebraska; Gano, resistant in New York. Others, as Wine-sap, Northern Spy, Baldwin, Spitzenburg, &c., were very susceptible to scab.

Among our trees especially susceptible to fire blight are: Yellow Transparent, Maiden Blush and Fall Pippin. In fact, in some orchards these varieties have been almost destroyed by this disease, appearing frequently in the form of body-blight and collar-rot. Varieties of apple show very noticed difference in resistance to rust.

I have noted in our nurseries and orchards that some varieties of peach of which Tilletson is a striking example, are much more subject to the white mildew. Scab resistant potatoes are on the market. The McCormack and other potato varieties seem more or less blight resistant. The Mildew on roses varies greatly with different varieties; the Rambler roses being very subject to it. The Lima bean is much troubled by the downy mildew when other beans are free from it.

It seems possible, judging from variation observed in our fields, that varieties of cabbage may be produced, resistant to black rot, for which destructive disease no remedy is now known. This principle will apply to other diseases as well.

The foregoing will serve as examples of what is being done in this line and indicate what can be done further in selecting and breeding. The resistant forms now in our possession may be used as the parents of still more resistant ones to be developed in the future, and also for crossing with less resistant, but more productive or otherwise desirable kinds to improve them.—(Trans. Peninsula Hort. Soc. 1908.)

SOIL INFESTING PARASITES IN FIELD AND FORCING HOUSE.

The cultivated soil is a medium in which many species of bacteria and fungi survive from year to year. The public is familiar with the doctrine of bacterial infection or inoculation of the soil in its relation to the nodules or tubercles of clover, alfalfa, soy beans, cowpeas and other cultivated plants of the Family of *Leguminosae.* One form of bacterium is not sufficient for both clover and alfalfa. This flora of the soil both in relation to bacteria and fungi of considerable range of species, is enriched by the applications of manure and by the practices of culture; by this is meant that the growing of a given crop a second time or a third time consecutively in the soil increases the probability that the plant roots remaining in the soil are carried over from one crop to the next together with root parasites which cause disease in the plants of this crop. Manifestly, likewise, if in preparation for a given crop to be grown for the first time upon the land, rather liberal applications are made of fresh stable manure containing spores or mycelium, more especially the resting forms of mycelium called sclerotia, the soil will become infected by this manurial application. While this source of infection is rather rare in field culture we have specific examples as in the scab disease of potatoes transmitted in this way; the scab of sugar beets may be carried in like manner. But in forcinghouse culture where heavy applications of manure are made, the chances are greatly increased that soil infection will be produced from the manure.

It is of value to remember that seed infesting or seed infecting organisms are also very largely capable of survival in the soil nidus of cultivated soils, thus our troubles multiply adequately if our care be inadequate to avoid them.—(Ohio E. S. B. 214.)

The Avoidance and Prevention of Soil Infesting Diseases.—We, perhaps, may assert that the law of nature is that of a diversified plant covering; at any rate the law of successful culture will permit of statement in terms of crop rotation. And it is true that as culture ages the number and seriousness of plant diseases increase almost in geometric ratio. It is further conspicuously true with respect to those areas devoted largely to continuous culture in a single crop or in a group of closely related crops such as the growing of wheat in Western United States and Canada, also in the growing of flax and other crops. Potato growing in San Joaquin county, California, illustrates this danger. Muck lands devoted to vegetable culture, tempt the grower to continue his crops of celery, onions, etc. Here we have as a true result the accumulation of diseases which attack these plants; thus for field culture we are constantly facing these problems of soil infesting diseases and the handling of the diseases is not an easy problem since change to rotation may mean a serious decrease in the return from the crop on the special type of soil. While for general field culture avoidance of conditions may be successful, this is by no means a simple matter. Rotation is often absolutely necessary, but this same rotation will not rid the soil of the onion smut fungus, nor of some other parasites such as in the case of the club-root fungus of cabbage and related plants. In these cases some soil treatment must be applied to field areas. In the case of the onion smut it is sufficient to apply a formalin drip which will fall with the seed and disinfect the soil layer in proximity to the seed. This is effective because the smut fungus can penetrate the germinating onion plant only in the earlier stages of growth. On the other hand with cabbage club-root, where plants are transplanted from the beds in which they are grown, some general method of soil treatment which involves the soil mass is more effective. In this case it is the application of stone lime or caustic lime in liberal quantities. These examples are only illustrative of general conditions to be met with. In the case of potato scab, it is found necessary both to disinfect the seed where scab is present, even to a limited extent, and to plant upon new soil not infested with the scab organism. Potato rosette is certainly an acid loving parasite.

Under the diseases described for each plant, methods of avoidance and treatment are indicated and the diligent student will find other instances of similar character mentioned therein.

SOIL TREATMENT IN THE FORCING HOUSE.

About our great centers of population have grown up conspicuous developments of the forcing house industry; large areas are covered with glass and these hothouses are maintained at the necessary temperatures for the production of the special green crops found profitable. At the same time the soil of the hothouse beds is very liberally manured and enriched further by applications of commercial fertilizers. Not only do these applications of manure tend to enrich the flora of the soil and to introduce particular root parasites, but the decay of the organic matter of the manure also tends to produce humus acids in considerable quantities. Along with these are brought parasitic eelworms which are peculiarly fatal to curcurbitaceous plants, to violets and to some other hothouse crops. Next to the eelworms the most conspicuous organism in our area is the sterile fungus Rhizoctonia, whose resisting forms or sclerotia may be readily introduced in manure. To meet this indoor soil infection, special methods of soil sterilization had to be developed, since soil rotation is practically impossible in the forcing house.

These methods of treatment are in brief, steaming of the soil to render it practically sterile, so far as these parasites are concerned, and a method of formalin drenching. This method of steaming is ideal, or almost so, in its results upon sandy or loamy soils, but often entails unfavorable changes in heavy silty or clay soils. Essentially, it consists in burying a series of perforated pipes in the soil and at intervals, covering the surface of the beds and passing live steam in sufficient volume into the pipes. These pipes are prepared in sets with cross heads and boiler connections and are perforated at desired distances. The surface of the bed is covered with canvas and the steam passed into the system for such period as is required to heat the soil to a temperature from 180° to

212° Fahr., to be maintained for one hour or more. This applies to high pressure boilers; for low pressure or hot water heating systems where the steam is applied in subdrains, four to five hours steaming will be required with a pressure of six to seven pounds. This treatment is effective for destruction of the eelworms or nematodes of cucumbers, violets and lettuce, the rot or drop fungus of lettuce, the rosette fungus, and in general of all soil infesting parasites.

Another method, the formaldehyde or formalin drench, has proved successful for the control of *Rhizoctonia* in greenhouse soils. This consists in a solution of 40 percent formaldehyde in water, say at the rate of two to four pounds in 50 gallons of water. This is applied at the rate of one gallon per square foot of area and will involve a very severe wetting down of the bed and prevent immediate resetting of the soil owing to the persistence of the formaldehyde. One secondary effect of formaldehyde drench and lime in sandy soils in the forcing house was an increased yield of lettuce amounting from 60 to 90 percent over the ordinary crop. This was explained on the assumption that the parasitic fungus was destroyed and certain other inhibiting organisms at the same time.

The Best Forcing House Practice.—The best forcing house practice will contemplate a recurrent disinfection or sterilization of the soil during the idle period; it should be preceded by whatever applications of the limestone and manure that are to be made to the soil, then after thorough working and application of water to correct unevenness of moisture the soil may be sterilized by steam, or the formaldehyde drench be applied with assurance of results: obviously also this treatment must extend most vigorously to the plant beds and bring healthy seedlings to soil in which the soil parasites have been destroyed.

The following tables of seed and soil treatments taken from the spray calendar will be of more use than extended description or discussion.—(Ohio E. S. B. 214.)

Seed and Soil Treatments.

SEED OR PLANT	FOR WHAT TREATED	TREATMENT	METHOD OF TREATMENT.
Barley	Smuts	Formaldehyde or modified hot water	Sprinkling with stronger formaldehyde as for oats is successful. Soak seed enclosed in sacks four hours in cold water, let stand wet four hours more and dip five minutes in hot water at 130 degrees Fahr., or three degrees lower than for other hot water treatments.
Bean	Anthracnose	(See spray calendar)	
	Weevil	Bisulfid of carbon	Submit to fumes for twenty-four hours in air-tight vessel or chamber.
Begonia	Nematodes	Sterilize soil with steam	Disinfect soil to be used by heating with steam as described under cucumbers.
Cabbage and Cauliflower	Club root	Quicklime on soil	Apply stone lime (quicklime) preferably ground lime, before planting, at rate of 80 bushels per acre and work into the soil with suitable tools.
	Maggot	Bisulfid of carbon or tobacco dust	Make hole in soil near root, pour in about a teaspoonful of bisulfid of carbon and fill holes with soil. Cover soil around stalks freely with tobacco dust once per week.
	Nematodes in hothouse	Sterilize soil with steam	See next.
Cucumber	Nematodes in hothouse	Sterilize soil with steam	Sterilize soil with steam by perforated pipes, high pressure, 1 to 2 hours, or low pressure in subdrains 4 to five hours.
	Root rot	Drench soil with formaldehyde or sterilize as above	Drench soil with formaldehyde 3 to 4 lbs. to 50 gallons of water preceding lettuce crop.
Lettuce	Rosette	Sterilize soil with steam or drench with formaldehyde	Steam as above or drench with formaldehyde 1½ to 2 lbs.; where trouble follows with cucumbers use 3 to 4 lbs. to 50 gals. of water, 1 gal. solution to each sq. ft. of surface. Two weeks must elapse before setting plants.
	Rot	Steam soil	
Oats	Anthracnose	Formaldehyde	Treat seed as stated in next to kill adhering spores. This is only a partial remedy.
	Loose smut	Sprinkle seed with formaldehyde or immerse seed in hot water. Soak seed in potas. sulfid	Preferably sprinkle a pile of seed with shoveling to saturate with formaldehyde solution, one gallon to bushel, at three or four sprinklings; after three or four hours or over night in the pile spread to dry. Immerse seed contained in open vessel for ten minutes in hot water at 132-3 degrees Fahr., for seven minutes at 136 degrees Fahr., or for five minutes at 140-2 degrees Fahr., spread at once to dry. Soak seed in ¾ per cent solution potassium sulfid for 24 hours with stirring, then dry.
	Insects in stored grain	(See wheat)	
Onion	Smudge	Use formaldehyde as for onion smut	Sow seed with formaldehyde as for onion smut; rotate onions with other crops.
	Smut	Use formaldehyde or ground quicklime. Plant other crop. Use sets or transplanted seedlings.	Use formaldehyde solution 1 lb. to 30 gals. of water sprinkled on seed in contact with soil and cover at once, or better sow with drill and drip attachment, the solution falling with the seed. Or apply ground quicklime at the rate of seventy-five to one hundred and twenty-five bushels per acre just previous to seeding on freshly plowed land, and stir into soil. (See bulletin 131).

Seed and Soil Treatments.—Concluded.

SEED OF PLANT	FOR WHAT TREATED	TREATMENT	METHOD OF TREATMENT
Onion	Storage-rots	Disinfect with formaldehyde gas	Fumigate to disinfect the dry onions, with formaldehyde gas in enclosed piles of slat crates for a period of 24 to 48 hours. (See description of method under fungicides.)
Pea	Anthracnose (Blight)	Spray the growing crop with Bordeaux	Keep down infection of seed through spraying of plants. See Spray Calender.
Potato	Scab	Soak uncut seed in formaldehyde or corrosive sublimate	Soak seed for two hours in formaldehyde or one hour in corrosive sublimate; then dry and plant on scab-free soil; formaldehyde gas may be used.
	Rosette (Rhizoctonia)	Soak seed in formaldehyde as for scab	Soak seed in formaldehyde as for scab; on infected soil use formaldehyde after manner in onion smut (See Bulletin 145.)
Roses	Nematodes in hothouse	Sterlize soil with steam	Heat soil with steam as described above; thoroughly disintegrated soil from sod one year or more old is less dangerous. Lime water stimulates affected plants but is not a remedy.
Rye	Anthracnose	Formaldehyde	Treat seed as for oats and wheat to kill spores. Remedy only partial.
Sweet Potato	Black-rot and Stem-rot	Formaldehyde	Soak or fumigate seed roots as for potato scab; discard old diseased hotbeds; drench slightly diseased beds with formaldehyde as for lettuce and tobacco. Then set plants on new soil.
Tobacco	Root rot and Bed-rot	Drench beds with formaldehyde or sterilize with steam	Drench beds in fall or early spring with formaldehyde 2 lbs. or more to 50 gals. water, 1 gal. to each sq. ft. Do not seed until smell of formaldehyde has disappeared.
Tomato	Nematodes in hothouse	Sterilize soil with steam	As for roses and cucumbers above.
	Point rot in hothouse	Mulch or sub-water	An insufficient water supply seems favorable to development of point rot of green tomatoes.
Turnip	Club root	Quicklime in soil	As for cabbage and cauliflower. Avoid succession of these crops.
Violet	Nematodes in hothouse	Heat soil with steam	The time for prevention is by soil treatment beforehand as for cucumbers above.
Wheat	Anthracnose	Formaldehyde	Sprinkling as for stinking smut may prove a partial remedy.
	Loose smut	Modified hot water	Soak seed four hours in cold water, let stand four hours more in wet sacks, immerse five minutes in water at 133 degrees Fahr. and dry.
	Stinking smut	Formaldehyde, hot water or copper sulfate	Sprinkle grain in piles with formaldehyde as for oats smut, 1 gal. or less per bushel and dry in same manner. Dip skimmed seed for ten minutes in hot water at 133 degrees Fahr. and dry on disinfected surface or immerse ten minutes in solution of blue vitriol (copper sulfate); dry with air slaked lime by shoveling. Use two pounds of blue vitriol to ten gallons of water. Grain may be sprinkled in piles with copper sulfate or formaldehyde as for oats. (See Bulletin 97.)
	Insects in stored grain	Bisulfid of carbon	Place one pound of bisulfid of carbon for each 2,000 pounds of grain in bins. Cover surface with blanket to hold the fumes which will spread through the mass, killing all insect life. Use in tight bins or buildings and do not use near fire of any description.

—(Ohio E. S. B. 214)

WINTER WORK AGAINST PLANT DISEASES.

Peach Yellows.—All peach trees which showed during last summer on some or all of the branches the prematuring fruit with its peculiar red spots on the outside and in the flesh, so characteristic of this disease, should have been marked for taking out at this time, if it was not possible to destroy them at once. Where the yellows inspectors were able to go this year, such trees will be found designated by a tag or some other easily recognized mark.

Trees in the second stage of yellows can be told by the slender shoots usually in bunches, and at this time, and even later, often still bearing the narrow yellow leaves produced by this disease. It is a matter of only another season before such trees will die of the disease in most cases; and if any fruit is borne it will be of very inferior quality. Such trees, moreover, become the sources from which infection may spread, until many other trees are involved. *Any tree showing these indications should be cut down and burned at once; the longer it stands the more damage is done to the orchard, for there is no cure.* Do not drag away the tree cut down, but either burn it where it stood or cut it into cord size and load into carts, burning all brush, etc., where made. An excellent plant is to put a lot of brush, including trimmings from the tree itself, straw, etc., among the branches and around the trunk of the tree, which is then set on fire. In this way the smaller parts are disposed of with no possibility of spreading the trouble, and the portion left can be utilized for firewood with safety.

Pear Blight.—The injury done by fire blight during the last season can be seen now with some ease by examining the affected trees. The diseased branches usually have the dead leaves still hanging at this time. Twigs and smaller branches showing the dead sunken bark, characteristic of the disease, should be carefully cut out. Make the cut not less than six inches below the lowest visible sign of the disease, and dip the knife in carbolic acid water after each cut to prevent the transfer of germs from cut to cut.

Cover promptly any large cut surface with some cheap oil paint. This will not only exclude these germs but many others, and will keep the stubs of branches, etc., from drying out. This should always be done in trimming trees for any purpose. The young trees should be kept pruned into such shape that cases of blight on the twigs can be cut out before the disease gets too close to trunk or main branches. Blooming spurs on the lower part of the tree are always a source of danger from this cause.—(Md. E. S. Cir. 61.)

Most of the body blight, especially on Kieffer pears, is from other causes. As this trouble often follows winter injuries, cracks, etc., the trees should be watched in early spring for the first indications of this disease, and the diseased portions cut away from the bark before it has time to spread.

Black Knot.—This trouble of plum and cherry is not difficult to control in itself. The difficulty lies in the removal of wild trees which are also affected, and which are the source of infection, even after the orchard has been cleared up in respect to the disease. The wild cherry trees, as well as the knots in the orchard, should be removed if one wants to develop an orchard of plum or cherry.

The knots are due to a presence of a fungus in the growing cells of the wood, causing an unusual development of those cells. After the knot is formed the fungus produces spores of two kinds—one developing in the early part of summer (June), the other towards fall. Both kinds cause new knots when they germinate and have a chance to grow. The remedy is to cut out all knots in the fall or winter, spraying in addition before buds start in the spring, to kill any spores that may have lodged on the tree.

General Directions.—The fruit grower should look after his own business and the interest of his investment in fruit trees sufficiently to cut out and destroy such trees as may be affected without waiting to be notified of their presence. It is impossible that the State Horticultural Inspectors should visit all places in a year's time. The owner or his tenant is on the place daily, and can keep closer watch on the conditions than is possible on an occasional visit on the part of an inspector. The owner should, as all good orchardists do, know his orchard before and after the inspector calls, and attend on his own account to the aids to the health of his orchard which he knows are necessary in this region—fungicides, insecticides, cultivation and other improved methods of management.

Judicious pruning of fruit trees is very essential—the removal of dead or drying, especially of diseased branches, should be attended to as surely as the shoeing of the horses. The annual spraying against fungi and insects should be as much a part of the year's work as plowing.

Piles of trash should not be left in or near the orchard or other fruit fields. They harbor many insects and diseases, besides being unsightly and useless. The brush fire is an excellent preventive measure. A fall fire for summer's trash and a spring fire for the prunings and trimmings from the orchard should be part of every farmer's calendar. Burn all trash not of value for fuel or stable use. Burn also the remains of rotten or dried up apples, pears, plums and peaches left on the trees, or under them, by the action of the rot fungi. It has been found that much of the rapid spread of these diseases in the early spring and summer is due to the spores holding over from the previous season on the partially decayed fruits, or to the development of especially active spores from fungi remaining dormant in these fallen mummies. Much can be done to check this loss by destroying them before spring.

In the case of field crops—if any have had serious diseases this season—do not use the same crop on the affected fields next year. Cabbage, cauliflower and turnips should not follow one another in a field where club root, black rot or soft heart (heart rot) has occurred, as each is affected by the same diseases that attack the others. Potatoes and beets should not follow each other for the same reasons on fields in which the scab is serious.—(Md. E. S. Cir. 61.)